FIBRE FORTIFICATION OF LONG TERM CARE DIETS

A Thesis Submitted to the College of

Graduate Studies and Research

in Partial Fulfillment of the Requirements

for the Degree of Doctor of Philosophy

in the College of Pharmacy and Nutrition

University of Saskatchewan

Saskatoon, Saskatchewan

By

Wendy Joanne Dahl

PERMISSION TO USE

In presenting this thesis in partial fulfillment of the requirements for a Postgraduate degree from the University of Saskatchewan, I agree that the Libraries of this University may make it freely available for inspection. I further agree, that permission for copying of this thesis in any manner, in whole or in part, for scholarly purposes, may be granted by the professor or professors who supervised my thesis work or, in their absence, by the Head of the Department or the Dean of the College in which my thesis work was done. It is understood that any copying or publication or use of this thesis or parts thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to the University of Saskatchewan in any scholarly use which may be made of any material in my thesis.

Requests for permission to copy or to make other use of material in this thesis in whole or part should be addressed to:

Dean

College of Pharmacy and Nutrition

University of Saskatchewan

Saskatoon, Saskatchewan S7N 5C9

ABSTRACT

Constipation is a serious problem for long term care residents, who are routinely prescribed laxatives and enemas. Fibre fortification of food offers an alternative which may be preventative and less invasive. It was determined that the addition of 4 grams of pea hull fibre (PHF) to usual foods consumed by elderly long term care residents was acceptable and resulted in increased bowel movement frequency per month (18.7 ± 9.4 to 20.1 ± 9.6; $p < 0.05$) for the population as a whole, and for the constipated subgroup (8.8 ± 1.0 to 12.6 ± 3.8; $p < 0.05$). While PHF did not decrease pharmaceutical laxative and enema use, monthly fruitlax administration significantly decreased. PHF, incorporated into baked products, diminished sensory attributes, but all characteristics were ranked acceptable. Textural quality of these same products was improved with the addition of PHF. In a survey, dysphagic institutionalized elderly were offered only 1.4 servings per day of breads and cereals, indicating a need for fibre fortification of pureed foods. The textural characteristics of commercial and institutional pureed foods were evaluated. Viscosities of the institutional pureed foods deviated from the pudding-like standard with five samples too viscous for determination and none met the 1mm standard for particle size. The effect of the addition of PHF on the sensory and textural attributes of pureed foods was assessed. Texture of pureed foods fortified with PHF, as evaluated by sensory volunteers, differed from those fortified with soy cotyledon fibre (SCF) ($p < 0.05$), which is typically used in commercial pureed foods. Grittiness was apparent with PHF. Adhesion, perceived viscosity and mouth-coating were rated as high (> 3) and neither was significantly correlated with the objective measures.

Viscosity characteristics of fibre-fortified pureed beef, potato, carrot and beef stew were determined and found to be similar to the pudding standard, and were significantly and directly related to incremental increases in microcrystalline cellulose (MCC) and SCF. PHF had similar effects as MCC. Fibre fortification is a realistic and cost-effective means of increasing fibre intakes of elderly and dysphagic institutionalized individuals. Whereas fibre fortification of baked products required little product development, pureed foods did. Fibre can function to produce the recommended consistency for pureed foods.

ACKNOWLEDGEMENTS

I gratefully acknowledge the guidance and wisdom of Dr. Susan Whiting and Dr. Bob Tyler who served as my supervisors and the contributions of my advisory committee members, Dr. Gord Zello, Dr. Leigh Campbell, Dr. Cyril Kendall, Dr. Don Hamilton and Dr. Phyllis Paterson. Thank you to Dr. Michael McBurney for serving as the external examiner, to Mr. Ken Fulcher and Ms. Rae Aust who shared my interest in fibre fortification, and to Mr. Gerald Henriksen for his excellent technical assistance.

The following financial support was received and greatly appreciated: Canadian Federation of Biological Sciences Travel Award (2004), Canadian Institutes of Health Research: Institute of Aging Age Plus Prize (2004), Canadian Home Economists Association Fiftieth Anniversary Scholarship (2003), Hope Hunt Graduate Scholarship (2003), NSERC Industrial Post-Graduate Scholarship (2001, 2002), Life Sciences Research Day - Best Overall Poster (2002), Canadian Society of Nutritional Sciences Gagnon Travel Award (2002), Dietitians of Canada Graduate Award in Clinical Dietetics (2001) and the College of Graduate Studies and Research Travel Award (2001, 2003).

Research funding was provided by Saskatchewan Agriculture, Food and Rural Revitalization, Regina, SK; National Research Council of Canada - Industrial Research Assistance Program, Ottawa, ON; Private Recipe Limited, Brampton, ON; Saskatchewan Pulse Crop Development Board, Saskatoon, SK; and Parrheim Foods, Saskatoon, SK.

PUBLISHED AND SUBMITTED

Manuscripts:

Dahl, W.J., Whiting, S.J. & Tyler, R.T. Assessing the textural characteristics of pureed foods. Journal of the American Dietetic Association, Accepted: February 2005. (Chapter 7)

Dahl, W.J., Whiting, S.J., Healey, A.D., Zello, G.A. & Hildebrandt, S.L. (2003). Increased stool frequency and fecal output occurs when finely processed pea hull fiber is added to usual foods consumed by elderly long term care residents. Journal of the American Dietetic Association, 103, 1199-1202. (Chapter 4)

Dahl, W.J., Whiting, S.J. & Tyler, R.T. Protein content of pureed diets: Implications for planning diets for long-term care residents. Submitted to the Canadian Journal of Dietetic Practice and Research. February, 2005. (Part of Chapter 6)

Abstracts:

Dahl, W.J., Whiting, S.J. & Isaac, T.M. Application of the DRI planning process to a long term care population offered pureed foods. Presented at CFBS, June 17-19, 2004. Vancouver, B.C.

Dahl, W.J. & Tyler, R.T. Textural characteristics of institutional and commercial pureed foods. Presented at the American Dietetic Association's 2003 Food & Nutrition Conference & Expo (FNCE). San Antonio, TX, October 25-28, 2003.

Dahl, W.J., Whiting, S.J. & Tyler, R.T. (2003). Fiber enhancement of pureed foods. The Journal of Nutrition, Health & Aging, 7, 235.

Whiting, S.J., Dahl, W.J., Healey, A.D., Hildebrant, S., Zello, G.A. & Lengyel, C.O. (2003). Snacks in a long term-care facility: Macronutrient analysis reveals low nutrient density. The Journal of Nutrition, Health & Aging, 7, 235.

Dahl WJ & Tyler RT. Addition of high fiber ingredients to pureed food systems. Proceeding of 12th World Congress of Food Science and Technology, Chicago, IL, July 12-16, 2003.

Jensen SL, Lynchuk JL, Dahl WJ & Keeler S. (2003). Suitability and nutritional content of pureed foods offered in acute care facilities. Canadian Journal of Dietetic Practice and Research, 64, 158.

Dahl WJ, Whiting SJ, Healey A, Zello GA & Hildebrant S. Effect of adding finely processed dietary fiber to foods of elderly in long term care. American Society for Clinical Nutrition New Orleans LA, April 2002 and the Canadian Federation of Biological Societies, Montreal, June 2002.

Dahl WJ, Whiting SJ, Sanden JL & Hildebrandt SL. (2002). Variability in protein content of meals and snacks offered in long term care facilities. Canadian Journal of Dietetic Practice and Research, 63, 152.

Dahl WJ, Furkalo R, Kish-Geer A & McGladdery C. (2001) Addition of pea hull fibre to pureed foods for use with dysphagic institutionalized elderly. Canadian Journal of Dietetic Practice and Research, 62, 150.

Dahl WJ, Whiting SJ, Zello GA & Stanger JD. (2001). The effect of finely processed fibre fortification and cooking time on the quality of cooked pudding. Journal of the American Dietetic Association. 2001; 101:A59.

Other Publications:

Dahl, W.J. (2004). Texture-Modified Food Production: A Manual for Food Production for Long Term Care Facilities. Toronto, ON: Dietitians of Canada.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

ADA	American Dietetic Association
AI	Average Intake
CHD	Coronary Heart Disease
CFGHE	Canada's Food Guide for Healthy Eating
GLC	Gas Liquid Chromotography
IOM	Institute of Medicine
HGA	Homogalacturonan
LDL	Low density lipoprotein
MCC	Microcrystalline cellulose
N	Newton
NDF	Neutral detergent fibre
SCF	Soy cotyledon fibre
SD	Standard Deviation
SPSS	Statistical Package for Social Sciences
PHF	Pea hull fibre
RGI	Rhamnogalacturonan I
TPA	Texture Profile Analysis

1. INTRODUCTION

1.1 Rationale

In a caring society, quality of life is of utmost importance for individuals residing in long term care facilities. Many long term care residents suffer from a number of chronic diseases and conditions for which numerous medications are prescribed. Nutritional interventions that treat or prevent health conditions or diseases, whilst reducing medication prescriptions, may improve the quality of life for these individuals. Although residents of long term care facilities range in age, most are seniors. The focus of this thesis will be on those long term care residents that are elderly, over the age of 70 years.

Many long term care residents suffer from constipation. Although constipation is best prevented by the consumption of a diet high in fibre (American Dietetic Association (ADA), 2002), laxatives and enemas are routinely prescribed. Current recommendations suggest that target intakes for men and women over the age of 70 years should be 21 and 30 g/day of dietary fibre, respectively (Institute of Medicine

(IOM), 2002). Long term care facilities in Saskatchewan offer an average of 14 g/day (Lengyel, Zello & Whiting, 2003), and intakes of fibre are as low as 9 g/day (Lengyel, 2002). The constipation which results from offering diets deficient in dietary fibre exacerbates care needs (Stewart, Mackenzie & Downie, 1997) and decreases the quality of life for elderly residents (Talley, O'Keefe, Zinsmeister & Melton, 1992; Glia & Lindberg, 1997). In Saskatchewan, the costs of laxatives and enemas are borne by the long term care residents and may average $30.00 to $50.00 per resident per month (Personal Communication, J. Taylor, August 2003), whereas the addition of 10 g/day of insoluble fibre to the diet may cost as little as a $1.00 per resident per month. Fortification of the diets of institutionalized individuals with insoluble fibre may provide a feasible and inexpensive way of improving health and quality of life without undue taxing of an already stressed health care system, and thus warrants investigation.

Fibre-enhancement of institutional diets is required for long term care residents to receive an adequate intake of fibre. The fibre-enhancement of regular institutional diets has been investigated (Clark & Scott, 1976: Hull, Greco & Brooks, 1980; Sandman, Adolfsson & Hallsman, 1983; Kochen, Wegscheider & Abholtz, 1985; Rajala, Salminen, Seppãnen & Vapaatalo, 1988; Hope & Down, 1986; Finlay, 1988; Castle, Beverly & Travis, 1992; Hankey, Cullen, Wynne, Death & Kenny, 1993; Rodrigues-Fisher, Bourguignon & Good, 1993; Gibson, Opalka, Moore, Brady & Mion, 1995; Selig & Boyle, 2001). However, the acceptability of fibre-enhancement, when using wheat bran as the fibre source, has been questioned (Kochen et al, 1985). As many elderly residents in long term care suffer from dysphagia (Sonies, 1999), they are served texture-modified foods, such as pureed foods, to facilitate swallowing. Pureed foods are often prepared from foods in the usual diet and, therefore, would also require fibre-enhancement. As pureed foods require processing to reach a smooth, homogenous texture, incorporation of a traditional fibre source, such as wheat bran, is not appropriate.

The fortification of institutional diets must span both regular and texture-modified diet consistencies, allowing elderly residents of long term care to be offered recommended levels of total fibre. However, fibre fortification may alter sensory acceptance of institutional foods. As the nutrient intake of many long term care residents is marginal and their nutritional status poor, fortification must not diminish food intake. Therefore, insoluble fibre fortification of institutional foods must maintain sensory acceptability, as well as achieve the desired textural qualities for texture-modified foods. Finely processed insoluble fibre, such as pea hull fibre, may be appropriate for fibre fortification of regular and texture-modified institutional foods. Research is required regarding the effectiveness of fortification of institutional foods with finely processed insoluble fibre, and the acceptability of the sensory and textural qualities of such foods.

Pea hull fibre may be successfully incorporated into foods prepared in long term care facilities and may improve bowel function and decrease laxative use in long term care residents. Baked goods, fortified with pea hull fibre, may have acceptable sensory and textural characteristics. It is not known if long term care residents consuming pureed foods would receive adequate amounts of products fortified with insoluble fibre, and thus, fibre fortification of pureed foods may be needed. Methods for the textural analysis of pureed foods need to be developed to assess fibre-fortified pureed foods. Pureed foods fortified with pea hull fibre may have acceptable flavour and textural qualities. How addition of the pea hull fibre modifies the textural characteristics of pureed foods to produce the recommended homogeneous, spoon-thick consistency will need to be explored.

1.2 Objectives

1.2.1 The Effect of Pea Hull Fibre on Bowel Habits and Food Acceptance in Long term Care Residents

It was hypothesized that finely ground pea hull fibre could be successfully incorporated into multiple cooked or baked foods prepared in a long term care facility with no decrease in food acceptance, and that the addition of 5 g/day of pea hull fibre would result in improved bowel function and decreased laxative use in long term care residents. The objectives for this study were:

i. To determine the level of dietary fibre offered in the regular menu of a long term care facility.

ii. To determine the effect on bowel movement frequency of the addition of a moderate amount of pea hull fibre to the diet of long term care residents.

iii. To determine the effect on laxative use of the addition of a moderate amount of pea hull fibre to the diet of long term care residents.

iv. To determine the effect on food acceptance of the addition of a moderate amount of pea hull to the diet of long term care residents.

1.2.2 Sensory and Textural Evaluation of Baked Goods Fortified with Pea Hull Fibre

It was hypothesized that baked goods fortified with pea hull fibre would have acceptable sensory and textural characteristics. The objectives of this study were:

i. To determine the effect of fortification with pea hull fibre on the textural characteristics of baked products.

ii. To determine the effect of fortification with pea hull fibre on the sensory characteristics of baked products.

iii. To determine the effect of fortification with pea hull fibre on the shelf life of baked products.

iv. To determine the effect of fortification with pea hull fibre on the physical characteristics of baked products.

1.2.3 Preparation of Grain-based Pureed Foods in Long Term Facilities and Their Intake by Dysphagic Long Term Care Residents

It was hypothesized that long term care residents consuming pureed foods may not receive adequate amounts of baked goods and other grain-based foods, and thus fibre fortification of pureed foods would be required. The objectives of the study were:

i. To determine the intake of grain-based foods by long term care residents consuming pureed foods.

ii. To determine the total fibre intake of long term care residents consuming pureed foods.

iii. To determine the frequency of preparation of grain-based pureed foods in long term care facilities.

1.2.4 Textural Characteristics of Pureed Foods

It was hypothesized that reliable and valid methods for the textural analysis of pureed foods could be identified and used to assess typical institutional, commercial pureed and fibre-fortified pureed foods. The objectives of this study were:

i. To assess the validity of the Bostwick Consistometer, the line spread test and a spoon-thickness test for the prediction of viscosity.

ii. To determine the suitability of the wet sieve method of particle size analysis for pureed foods.

iii. To determine if objective measurements of hardness, cohesiveness and adhesiveness were suitable for the evaluation of a wide variety of puree-consistency foods.

1.2.5 Development and Characterization of Pureed Foods Fortified with Pea Hull Fibre

It was hypothesized that the replacement of soy cotyledon fibre, commonly used in pureed foods, with pea hull fibre will not result in a discernable texture or taste difference in pureed foods.

The objectives of this study were:

i. To develop pureed products, i.e. meat, vegetable, starch and casserole, fortified with pea hull fibre that maintained their form during the freeze-thaw-reheat cycle, using beef, carrot, potato and beef stew as the model pureed foods.
ii. To determine if there was a sensory difference between pureed beef, carrot, potato and stew fortified with soy cotyledon fibre or pea hull fibre.
iii. To perform descriptive analysis of the sensory characteristics of pureed foods fortified with pea hull fibre.

1.2.6 Viscosity Characteristics of Pureed Foods Fortified with Fibre

It was hypothesized that the addition of high-fibre ingredients would modify the textural characteristics of pureed foods and function to produce the recommended homogeneous, spoon-thick consistency. The objectives of this study were:

i. To describe the viscosity characteristics of pureed foods fortified with soy cotyledon fibre and microcrystalline cellulose.
ii. To describe the effect of incremental changes in the levels of microcrystalline cellulose and xanthan gum on the viscosity of pureed foods.
iii. To determine the ideal ratios of soluble to insoluble fibre for maintaining the form of pureed foods, i.e. vegetable, meat and casserole, during the freeze-thaw-reheat cycle.

2. LITERATURE REVIEW

2.1 Residents of Long term Care Facilities

The average age of the Canadian population is estimated to increase by 10 years in the next 50 years. By 2011, one in six Canadian will be a senior, and by 2026 this will rise to one in five (Health Canada, 2002). The greatest increase is predicted among seniors that are eighty-five years of age and older, with an expectation of a four fold increase by 2041 (Lindsay, 1999). At present, seniors are a large segment of Saskatchewan's population, with one in seven residents over 65 years of age (Saskatchewan Health, 2002). Life expectancy in Saskatchewan is currently 81.8 years for women and 75.4 years for men, which is slightly above the Canadian average (Saskatchewan Health, 2002).

Many seniors require high levels of care offered in long term care facilities. Long term care services in Saskatchewan are provided by long term care facilities at a level of 118 special care beds per 1000 individuals over the age of 75 years

(Saskatchewan Health, 2002). As of March 31, 2002, there were 158 funded long term care facilities and thirty-two hospital-based long term care units in the province (Saskatchewan Health, 2002). Long term care services include long term stays, respite services and adult day programs. Admission to long term care facilities in Saskatchewan is based on need following a detailed assessment. The average age of residents in long term care facilities in Saskatchewan in 2002 was 82.2 years (Saskatchewan Health, 2002). Long term care facilities are subsidized by the Saskatchewan government and funds are administered through the health regions. In addition, residents pay a charge based on annual income. On average, 23% of the total cost of long term care services is borne by the resident (Saskatchewan Health, 2002). Residents are also responsible for the costs of medications and personal supplies.

2.1.1 Health Status of Elderly Requiring Long term Care Services

Most residents of long term care facilities in Saskatchewan require assistance in all areas of daily life (Saskatchewan Health, 2002). The diagnosis most responsible for admission to long term care is dementia, although most residents have a multiple of debilitating conditions and diseases (Saskatchewan Health, 2002). Elderly long term residents suffer from arthritis, osteoporosis, renal disease, pulmonary conditions, hypertension, cancer and the incapacitating effects of stroke (Saskatoon Health Region, 2003).

The prevalence of malnutrition in residents of long term care facilities within Canada has been estimated at greater than 45% (Keller, 1993), and in Saskatchewan long term care facilities, at 50% (Arnold, Dahl, Poirier, Torgerson, Shavron & Colwell, 2003). Malnutrition may be present on admission from the community (Payette, Coulombe, Boutier & Gray-Donald, 1999) or hospital (Sullivan, Sun & Walls, 1999), but may also develop while in institutional care (Keller, 1993).

A significant number of residents of long term care are dysphagic (swallowing disordered) due to neurological disease or injury (Finiels, Strubel & Jacquot, 2001). The prevalence of dysphagia in Saskatchewan is not known. Dysphagia contributes significantly to the risk of malnutrition, morbidity and mortality of long term care residents (Langmore, Skarupski, Park, Fries & Brant, 2002; Loughlin, 1989).

Long term care residents are frequently hospitalized, with average lengths of stay longer than those under the age of 65 years (Saskatchewan Health, 2001). The presence of cognitive impairment significantly increases hospitalization and recovery times (Manitoba Health, 2000).

2.1.2 Food and Nutrient Intake in the Institutionalized Elderly

Sedentary lifestyle and reduced lean body mass in the elderly result in reduced caloric requirements, which may lead to reduced caloric and nutrient intakes (Payette, Gray-Donald, & Cyr, 1995). Functional and cognitive limitations further contribute to reduced energy and nutrient intakes in the elderly (Payette et al, 1995). Reduced appetite, due to medications or depression, or both, can also limit food intake (Huffman, 2002). Requirements for many nutrients, however, increase with age (IOM, 2002). Lengyel (2002) reported that average energy intakes by institutionalized elderly averaged less than 1500 kcal/day and intakes of a number of nutrients, specifically folate, magnesium, zinc, and Vitamins E, B_6, B_{12}, C and thiamin, were found to be inadequate. Another recent Canadian study found that the energy intake of long term care residents ranged from 1000-1500 kcal/day (Wendland, Greenwood, Weinberg & Young, 2003).

The fibre intake of institutionalized elderly has been investigated (Dror, Stern, Nemesh, Hart & Grinblat, 1996; McCargar, Hotson & Nozza, 1995; Laurin, Brodeur, Bourdages, Vallee & Lachapelle, 1994; Johnson, Roth, Reinhardt & Marlett, 1988; Lengyel, 2002), and has been reported to vary widely. However, the lowest intakes were reported by Lengyel (2002), with institutionalized elderly in Saskatchewan consuming an average of only 9.1 g/day. The low total fibre intakes were dependent, in part, by the amount of fibre provided in the menus as these were found to offer no more than an average of 14 g/day of total fibre (Lengyel et al, 2003). As the Adequate Intake (AI) for total fibre is 21 g/day for women and 30 g/day men over 70 years of age (IOM, 2002), the provision of dietary fibre in long term care menus is insufficient for residents to achieve recommended intakes of total fibre.

Deficits of nutrients might be overcome through supplementation. However, the effects of the process of supplementation on the quality of life of institutionalized elderly are not known, and supplementation of macronutrients may simply not be feasible. Instead, fortification of foods may be an appropriate route for nutrient enhancement of foods intended for the institutionalized elderly. The fortification of foods in the institutional diet will result in foods that are more nutrient-dense. However, little investigation into the acceptance of fortified or novel foods has been undertaken (Poucherot & Issanchou, 1998), and little research has been carried out related to food preferences in the elderly. Nutrient fortification of foods may influence acceptability, as de Jong, Chin, de Graaf, Hiddink, de Groot and van Staveren (2001) found decreased pleasantness scores for micronutrient-dense versus control fruit and dairy foods evaluated by frail, free living elderly. In addition, Kochen, Wegscheider & Abholtz (1985) found that bran-enhanced foods were unpalatable to elderly hospitalized patients. Foods could be developed to optimize the provision of fibre, but palatability and overall acceptability would require assessment.

2.2 Constipation in Residents of Long term Care Facilities

Constipation is a common health problem (Talley et al, 1992) which negatively impacts quality of life (Glia & Lindberg, 1997) and can be defined as "difficult evacuation, associated straining, prolonged passage of stool, pain and incomplete evacuation". In practice, however, constipation is often defined by bowel frequency, i.e. two or fewer bowel movements per week (Wilson, 1999; Towers, Burgio, Locher, Merkel, Sataeian & Wald 1994; Dukas, Willet & Giovannucci, 2003). Complications and side effects of constipation can include hernia, anorexia, early satiety, cardiovascular events, psychological effects such as confusion, and gastrointestinal obstructive and inflammation (Alessi & Henderson, 1988). Constipation has been inversely related to fibre intake, body mass index, physical activity, alcohol and smoking use (Dukas et al, 2003), but the elderly are at increased risk of constipation due to medication use, immobility and disease conditions (Schaeffer & Cheskin, 1998; Wilson, 1999).

Constipation in elderly residents of long term care homes is multi-factorial. There are a number of mechanical conditions that are associated with constipation in the elderly, such as colon cancer and strictures (Romero, Evans, Fleming & Phillips, 1996). Metabolic conditions such as diabetes, hypothyroidism, electrolyte abnormalities and uremia can contribute to constipation (Romero et al, 1996). Certain disease states such as Parkinson's disease, multiple sclerosis and spinal cord injuries are also associated with constipation (Read, Celik & Katsinelos, 1995). Numerous constipating medications are prescribed to residents of long term care facilities, including calcium channel blockers, diuretics, narcotics, antipsycotics, tricyclic antidepressants, anti-parkinsonian drugs and others (Read et al, 1995).

Although inadequate fluid intake is commonly attributed to constipation in the elderly, this premise remains unsubstantiated. Only a single study in healthy young men has demonstrated decreased stool output and stool frequency with daily fluid intakes of less than 500 mL compared to 2500 mL (Klauser, Beck, Schindlbeck & Muller-Lissner, 1990), and the authors do not indicate if symptoms of constipation resulted from the fluid restriction. Chung, Parekh and Sellin (1999) reported no significant increase in stool output with the addition of one to two liters of isotonic or hypotonic water to the diets of healthy volunteers. Anti, Pignataro, Armuzzi, Valenti, Iascone, Marmo, Lamazza, Prearoli, Pace, Leo, Castelli and Gasbarrini (1998) reported that mineral water improved stool frequency. However, magnesium, among other cations, and anions such as sulfate were present in the supplemental water and may account for the laxative effects. Additional research is required to investigate the effects of fluid intake and dehydration on constipation. Inadequate intakes of fibre may be a more significant reason for the high prevalence of constipation in the institutionalized elderly.

2.2.1 Treatment and Prevention of Constipation in Long term Care Facilities

Bowel movement frequency and output of long term care residents are often monitored and recorded in charts, particularly with residents requiring assistance with toileting. The phrase "bowel care" is used in long term care facilities and in the published literature to describe treatment plans for constipation. Bowel care treatment plans often include laxatives and enemas, which are prescribed by attending physicians and administered by nurses as ordered or as need is perceived (Dahl & Wasko-Lacey, 1999). Although laxatives and enemas are prescribed and administered to many long term care residents, actual rates for constipation of long term care residents are not known, nor is it known if the laxative administration reflects actual clinical constipation. The monitoring and recording of bowel habits and the administration of laxatives and enemas may require significant nursing time.

Prevention of constipation, through supplemental fibre to the diets of the institutionalized elderly, has been investigated (Clark & Scott, 1976: Hull et al, 1980; Sandman et al, 1983; Kochen et al, 1985; Rajala et al, 1988; Hope & Down, 1986; Finlay, 1988; Castle et al, 1992; Hankey et al, 1993; Rodrigues-Fisher et al, 1993;

Gibson et al, 1995; Selig & Boyle, 2001). Fibre supplementation has been shown to reduce constipation or decrease laxative use, or both. However, fibre supplementation has not been successful in the long term management of constipation and fibre fortification of long term care diets has not become the norm. The literature provides possible explanations as to why fibre fortification of long term care diets has not seen widespread implementation. Most studies have used wheat bran, and although wheat bran is one the most effective fibre sources for the treatment of constipation, it alters the texture and flavour of foods and has been shown to be unpalatable (Kochen et al, 1985). Some studies have used a single fibre-fortified food or supplement (Hull et al, 1980; Rajala et al, 1988; Hankey et al, 1993). This approach poses an additional problem, as providing fibre in a single food or supplement requires long term care residents to consume that specific food or supplement. The administration of a specific food or fibre supplement requires nursing time (Clark & Scott, 1976; Hankey et al, 1993), and repetition may result in declining consumption or rejection of the food or fibre supplement (Hankey et al, 1993).

2.2.2 Common Pharmaceutical Laxatives and Enemas

Although research supports the efficacy of fibre in the prevention and treatment of constipation, pharmaceutical laxatives and enemas continue to be used as the primary treatment for constipation and to regulate bowel function in the institutionalized elderly (Lederle, 1995; Wolfsen, Barker & Mitteness, 1993). As many as seventy percent of long term care residents are prescribed laxatives (Quail, 1998).

The laxatives most commonly prescribed for the elderly fall into the categories of emollients, stimulants and saline laxatives. Mineral oil, an emollient, is not recommended due to its risk of aspiration and resulting lipoid pneumonia (Wright & Jeffery, 1990). Docusate sodium, another emollient, is the most commonly prescribed laxative for the elderly (Harari, Gruwitz & Minaker, 1993). Although this medication poses little risk, its long term effectiveness in treating constipation is questionable (Castle, Cantrell, Isreal & Samuelson, 1991). Commonly prescribed stimulant laxatives are senna and bisacodyl, but these have possible side effects of electrolyte losses and dehydration (Harari et al, 1993) and malabsorption (Roe, 1986). Prolonged use of stimulant laxatives may result in bowel dependency (Harari et al, 1993; Lederle, 1995). Saline laxatives, most commonly magnesium salts, may be effective but can result in hypermagnesiumia in elderly individuals with age- and disease-related reductions in kidney function (Lederle, 1995).

Enemas, usually only recommended for the most difficult cases of constipation, are commonly used in bowel care regimes (Quail, 1998; Dahl & Wasko-Lacey, 1999). Fluid and electrolyte abnormalities and dehydration may occur if used incorrectly (Allesa, 1988). Another possible side effect is damage to the rectal mucosa (Romero et al, 1996). The effect of enema administration on quality of life of elderly individuals is not known. However, the experience of having an enema administered may impinge on the dignity of the individual.

2.2.3 Food-sourced Laxatives

Hyperosmolar laxatives, such as lactulose and sorbitol, are non-digested sugars that may reduce constipation as a result of the osmotic potential created in the intestinal lumen (Lederle, 1995). Lactulose and sorbitol appear safe for long term use in the elderly, as only minor side effects, such as bloating and flatulence, have been reported (Lederle, 1995). However, there is evidence to suggest that the gut can become accustomed to unabsorbed sugars and thereby lessen the osmotic and laxative effects of these sugars. Research on lactose malabsorption supports this hypothesis, as lactose malabsorption may not result in remarkable increases in transit time and laxative effects in acclimated guts (Lee & Krasinski, 1998). The colonic bacteria population can accommodate increases in substrate by fermenting the unabsorbed sugars in the right ascending colon resulting in little stool bulking and thus eliminating the osmotic effect of the unabsorbed sugar. Although the osmotic effects of short chain fatty acids also has been indicated as a possible explanation for the laxative effect of malabsorbed sugars, these products of bacterial fermentation are quickly absorbed, reducing the osmotic load (Cummings, 1984). Evidence for gut acclimation is suggested by the need for increasing levels of lactulose over time to provide an equivalent laxative effect (Canadian Pharmaceutical Society, 2002). Further, the requirement of many elderly institutionalized individuals for laxatives in addition to lactulose (Dahl & Wasko-Lacey, 1999) provides evidence that the laxative effect of lactulose may lose its effectiveness over time.

Prunes and prune juice have traditionally been recommended for the treatment constipation and many long term care residents are given fruitlax, a prune containing fruit puree. Some studies investigating the functional effect of fibre-enhancement of long term care diets have used prune puree or prune juice in the high fibre formulations (Gibson, Opalka et al, 1995). It has been suggested that prunes (also called dried plums) may contain diphenylisatin (Baum, Sanders & Straub, 1951), a stimulant laxative once common ingredient in laxative preparations. More recent research has shown that prunes contain large amounts of phenolic compounds, some of which may have laxative actions (Stacewicz-Sapuntzakis, Bowen, Hussein, Damayanti-Wood & Farnsworth, 2001). Prunes are also known to contain sorbitol, a known osmotic laxative (Stacewicz-Sapuntzakis et al, 2001). Although there are hundreds of years of anecdotal reports of the laxative effects of prunes, very little research has been carried out on the efficacy of prunes. One study of forty-one men consuming twelve dried prunes (100 g/day; 6g fibre) produced a 20% increase in fecal weight (Tinker, Schneeman, Davis, Gallaher & Waggoner, 1991). The fibre content may have been a factor in the laxative effect of the prunes.

Psyllium, a purified fibre source and not a pharmaceutical, is often recommended for the treatment of constipation and has been shown to have significant laxative effects (McRorie, Daggy, Morel, Diersing, Miner & Robinson, 1998). It is often given as a suspension, but as psyllium has tremendous water-holding capacity and can become very viscous, it is recommended that additional fluid be consumed with the psyllium slurry. Psyllium poses a risk of esophageal obstruction, particularly in individuals with swallowing disorders (DiPalma & Brady, 1987).

2.3 Dietary Fibre and Human Health

2.3.1 Fibre Chemistry

With the exception of lignin, a complex aromatic compound, dietary fibre is comprised of non-starch polysaccharides. Cellulose, a linear polymer of (1→4)β-D-glucan, is the most common plant-sourced fibre (McCleary & Prosky, 2001). Non-cellulosic polysaccharides include glucuronoarabinoxylans, linear chains of (1→4)β-D-xylan interspersed with single units of xylose or glucuronic acid; mannans, linear chains of (1→4)β-D-mannose; glucomannans, linear chains of (1→4)β-D-mannose and (1→4)β-D-glucose; and galactomannans, linear chains of (1→4)β-D-mannose with (1→4)β-D-galactose side chains (McCleary & Prosky, 2001). Pectic fibres include homogalacturonan (HGA), helical polymers of (1→4)β-D-galacturonic acid, and others such as rhamnogalacturonan I (RGI) and xylogalacturonan having HGA backbones (McCleary & Prosky, 2001). Other fibres include: β-glucans, polysaccharides of branched glucose residues (β-D-glucopyranose) found in fungi, algae, barley and oats; inulin, oligofructose and fructo-oligosaccarides, β-(2,1) fructans with a terminal glucose unit; and psyllium, an unusual highly viscous mucilage fibre (IOM, 2002).

2.3.2 Dietary, Functional and Total Fibre

"*Dietary fibre* consists of nondigestible carbohydrates and lignin that are intrinsic and intact in plants. *Functional fibre* consists of isolated, non-digestible carbohydrates that have beneficial physiological effects in humans. *Total fibre* is the sum of *dietary fibre* and *functional fibre*" (IOM, 2002). The reasoning for a separate definition for *dietary fibre* is based on the difficulty of separating the health benefits of fibre per se and the other nutrients that are often associated with the fibre intrinsic in plant foods. Providing a separate category for *functional fibre* allows the health-enhancing characteristics of these fibres to be highlighted.

The American Association of Cereal Chemists defines dietary fibre as "the edible part of plants and analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the human large intestine. Dietary fibre includes polysaccharides, oligosaccharides, lignin and associated plant substances. Dietary fibre promotes beneficial physiological effects, such as, laxation, and/or blood cholesterol attenuation, and/or blood glucose attenuation" (McCleary & Prosky, 2001).

Fibre can be further subdivided into viscous and low viscosity fibre (Nelson, 2001). The use of the terminology "viscous" and "low viscosity" fibre allows descriptions and explanations of both food and physiological functions (McCleary & Prosky, 2001). Physiological viscous fibres are those that slow digestion and absorption and delay gastric emptying. Viscous versus low viscosity fibre ingredients is an arbitrary division with most soluble fibre ingredients being categorized as viscous and insoluble fibre ingredients classified as low viscosity fibres. Fibre may also be described as fermentable and non-fermentable when large-intestinal physiological descriptions and explanations are required, but as only lignin alone is completely resistant to human intestinal fermentation, more appropriate terminology would be "less fermentable" and "highly fermentable" (Cummings & Bingham, 1987). Fibre has also been traditionally divided into soluble and insoluble fibre, but it has been suggested that these terms be phased out (IOM, 2002). However, the designations of soluble and insoluble are based on analytical methodology (McCleary & Prosky, 2001), and are useful in describing food functionality.

Fibre can be analyzed by a number of methods. Enzymatic-gravitational methods, such as the neutral detergent fibre (NDF) method of Van Soest and Wine (1967), include enzymatic removal of starch (a modification of the procedure by Scaller, 1977), ethanol precipitation of soluble dietary fibre, isolation of dietary fibre residues and correction for protein and ash. The Southgate method (1992) is an enzymatic-chemical method used to measure unavailable carbohydrate by the removal of starch and "the extraction or precipitation of soluble dietary fibre polysaccharides from low-molecular weight sugars and starch hydrolysis products" (McCleary & Prosky, 2001). The Englyst method (Englyst & Cummings, 1984) is a "GLC method for characterization of gravimetrically-determined soluble and insoluble dietary fibre residues". This method has an additional step of resistant starch removal and identification.

Resistant starch [α- (1-4), α- (1-6) and (1-2), (1-3) linkages], resulting from heat and enzymatic treatment of starch, is included as functional fibre, and the inclusion of resistant dextrins is pending sufficient data on the physiological benefits in humans (IOM, 2002).

2.3.3 Health Effects of Fibre

Fibre enhances a number of physiological functions. Viscous fibres delay gastric emptying (Low, 1990; Roberfroid, 1993) and absorption of glucose (Jenkins et al, 1978). The addition of viscous fibre reduces the glycemic response of the carbohydrate-containing foods (Jenkins & Wolever, 1993; Jenkins, Jenkins, Wolever, Vuksan, Rao, Thompson & Josse, 1994). Viscous fibres, such as pectin, guar and β-glucan, lower postprandial glucose in most studies. However, insoluble fibres have much less of an effect, with most studies demonstrating no effect (Wolever & Jenkins, 1993). Cellulose does not affect postprandial glycemic response (Librenti, Cocchi, Orsi, Pozza & Micossi, 1992; Niemi, Keimänen-Kiukaanniemi & Salmela, 1988).

The luminal-viscosity enhancing characteristics of viscous fibre can reduce bile acid reabsorption and improve cholesterol profiles (Jenkins et al, 1994) and the absorption of energy (Heaton, 1973). A variety of fibres have been found to contribute to decreased blood lipid concentrations. Guar gum has been found to lower serum cholesterol (Jenkins, Newton, Leeds, & Cummings, 1975). Feeding inulin has shown cholesterol-lowering properties (Brighenti, Casiraghi, Canzi & Ferrari, 1999), but others have found no effect (Pedersen, Sandstrom & van Amelsvoort, 1997; Luo, Riskalla, Alamowitch, Boussairi, Blayo, Barry, Lafitte, Guyon, Bournet & Slama, 1996; Van Dokkum, Wezendonk, Srikumar & van den Heuvel, 1999). Pectin reduces both total cholesterol and LDL cholesterol (Cerda, Robbins, Birgin, Baumgartner & Rice, 1988; Durrington, Manning, Bolton & Hartog, 1976). Psyllium also significantly reduces serum total and LDL concentrations (Anderson & Gustafson 1988; Anderson, Allgood, Turner, Oeltgen & Daggy, 1999; Anderson, Allgood, Lawrence, Altringer, Jerdack, Hengehold & Morel, 2000; Davidson, Maki, Kong, Dugan, Torri, Hall, Drennan, Anderson, Fulgoni, Saldanda & Olson, 1998; Abraham & Mehta, 1988; MacMahon & Carless, 1998). Further, oat gum (β-glucans) has been shown to reduce LDL cholesterol in hypercholesterolemic subjects (Braaten, Wood, Scott, Wolynetz, Lowe, Bradley-White & Collins, 1994; Davidson, Dugan, Burns, Bova, Story & Drennan, 1991)

Soluble fibre and to a lesser extent, insoluble fibre sources, are fermented in the colon, resulting in moderate fecal bulking and the production of short chain fatty acids; namely butyrate, propionate and acetate (Cummings, 1981a). Butyrate, the preferred substrate of the colonic mucosa cell (Roediger, 1982), may be preventative in colonic cancer (Cummings, 1981b; Lupton, 1995). Lack of butyrate production in the colon or reduced absorption and metabolism of butyrate in the colonocyte, or both, may contribute to the pathogenesis of ulcerative colitis (Roediger et al, 1993). Gums (e.g. galactomannans) are highly fermentable, soy fibre is intermediate, and psyllium and hull fibres are less fermentable (Bourquin, Titgemeyer, Fahey & Garleb, 1993). Depending on the extent of fermentation, dietary fibre provides energy in a range from 1.5 to 2.5 kcal/g (Livesey, 1990; Smith, Brown & Livesey, 1998).

The consumption of fibre has long been known to prevent and treat constipation (Dimmock, 1937), as a result of fecal bulking and decreased transit time (Cummings, 1981a). A meta-analysis of more than one-hundred studies of fibre effects on stool weight indicates that wheat bran has a fecal bulking capacity of 5.7 g/g of bran fed and cellulose produces 3 g/g of cellulose fed, but pectin provides only 1.3 g/g of bulking capacity (Cummings, 1993). Inulin has also been found to increase fecal weight (Gibson, Beatty, Wang & Cummings, 1995) by 2.0 g/g of inulin fed (Kruse, Kleesen & Blaut, 1999) and to decrease constipation (Kleesen, Sykura, Zunft and Blaut, 1997). Psyllium, although soluble, increases stool weight and stool frequency (Ashraf, Park, Lof & Quigley, 1995; McRorie et al, 1998) and has been found to improve bowel function in the elderly (Burton & Manninen, 1982). Guar gum, a highly fermentable fibre, has little effect of bulking (Slavin, 1987). However, resistant starch causes a small increase in fecal bulk (Phillips, Muir, Birkett, Lu, Jones, O'Dea & Young, 1995; Behall & Howe, 1996; Cummings, Beatty, Kingman, Bingham & Englyst, 1996; Heijneen, Van Amelsvoort, Deurenberg & Beynen, 1998; Hylla, Gostner, Dusel, Anger, Bartman, Christl, Kasper & Scheppach, 1998). The fecal bulking effect of finely processed fibre has also been investigated. Dramatic reduction in the particle size of wheat bran has been shown no have no effect on laxation (Jenkins, Kendall, Vuksan, Augustin, Li, Mehling, Parker, Faulkner, Seyler, Vidgen & Fulgoni, 1999). Finely processed oat hull (Stephen, Dahl, Johns & Englyst, 1997) and pea hull fibre (Guedon, Ducrotte, Antoine Denis, Colin & Lerebours, 1996) also have been shown to retain significant laxative effects.

2.3.4 Health Benefits and Requirements of Dietary Fibre

The relationships between dietary fibre, functional fibre, and the prevention of hyperlipidemia, hypertension, and coronary heart disease (CHD) have been recently reviewed (IOM, 2002). Numerous epidemiological studies have found reduced rates of

CHD in individuals consuming higher levels of dietary fibre (Fraser, Sabaté, Beeson & Strahan, 1992; Jacobs, Meyer, Kushi & Folsom, 1998; Morris, Marr & Clayton, 1977; Rimm, Ascherio, Giovannucci, Spiegelman, Stamfer & Willet, 1996; Wolk, Manson, Stampfer, Colditz, Hu, Speizer, Hennekens & Willet, 1999). Intervention studies demonstrate cholesterol lowering effects of viscous fibre (Brown, Rosner, Willett & Sacks, 1999; Ripsin, Keenan, Jacobs, Elmer, Welch, Van Horn, Liu, Turnbull, Thye, Kestin, Hegsted, Davidson, Davidson, Dugan, Demark-Wahnefried & Beling, 1992). Hypothetical calculations from epidemiological studies indicate relative risk reductions for CHD of 3.3% (Rimm et al, 1996), 2.02% (Wolk et al, 1999) and 1.71% (Pietinen, Rimm, Korhonen, Hartman, Willett, Albanes & Virtamo, 1996) per gram of fibre. This, combined with the evidence for cholesterol lowering properties of viscous fibre in clinical trials, as well as the reduced risk of CHD risk associated with cereal foods, provide evidence for the AI recommendation. Further evidence on the benefit of increased fibre on the risk of duodenal ulcers (Aldoori, Giovannucci, Stampfer, Rimm, Wing & Willett, 1997), fecal weight (Birkett, Jones, de Silva, Young & Muir, 1997; Cummings, 1993), butyrate production (Roediger, 1980), risk of diverticular disease (Aldoori, Giovannucci, Rimm, Wing, Trichopoulos & Willett, 1994; Aldoori, Giovannucci, Rimm, Ascherio, Stampfer, Colditz, Wing, Trichopoulus & Willett, 1995) and diverticulitis prevention (Finlay, Smith, Mitchell, Anderson & Eastwood, 1974; Brodribb, 1977), colon cancer (Lanza, 1990), and prevention (Salmerón, Ascherio, Rimm, Colditz, Spiegelman, Jenkins, Stampfer, Wing & Willett, 1997a; Salmerón, Manson, Stampfer, Colditz, Wing & Willett, 1997b), and treatment of diabetes

(Wolever & Jenkins, 1993) has been used to determine the AI recommendation. An additional prebiotic effect of increasing in fecal bifidobacteria is seen with inulin supplementation (Bouhnik, Flourié, Riottot, Bisetti, Gailing, Guibert, Bournet & Rambaud, 1996; Bouhnik, Vahedi, Achour, Attar, Salfati, Pochart, Marteau, Flourié, Bournet & Fambaud, 1999; Buddington, Williams, Chen & Witherly, 1996; Tuohy, Kolinda, Lustenberger & Gibson, 2001; Williams, Witherly & Buddington, 1994). Further work is needed to explore the relationship between fibre intake and breast and other cancers, and the relationship between satiety, weight maintenance and fibre intake remains to be resolved.

Because the evidence suggests that the beneficial effects of fibre in humans are most likely related to the amount of food consumed, and not to the individual's age or body weight, an AI based on grams per 1,000 kcal (IOM, 2002) was set. An Estimated Average Requirement could not be set due to the continued benefit of increased fibre intakes. Total fibre was set at 14g per 1,000 kcal multiplied by the median energy intake for each age group. The AI for elderly women and men is, therefore, set at 21 and 30 g/day, respectively.

Dietary fibre consumption is not, without adverse effects. Although mineral bioavailability has often been suggested as an adverse effect of dietary fibre, it has been shown that it is the phytate content of some fibre sources, not the dietary fibre content that may impair bioavailability (Brune, Rossander-Hulten, Hallberg, Gleerup & Sandberg, 1992; Dahl, Whiting & Stephen, 1995). Gastrointestinal distress is another possible side effect of fibre consumption. In one study, high intakes of wheat bran did not contribute to gastrointestinal distress (McRorie, Kesler, Bishop, Fillon, Allgood, Sutton, Hunt, Laurent & Rudolph, 2000). However, increased flatulence with increased intakes of dietary fibre has been shown (Bolin & Stanton, 1998; Tomlin, Lowis & Read, 1991). A high intake of dietary fibre, however, will not produce significant adverse effects in healthy individuals (IOM, 2002), and as fibre intake from food sources is self-limiting, a Tolerable Upper Intake Level for fibre has not been set.

Isolated and synthetic fibres have been studied for their adverse effects. Gums have been shown to produce flatulence in elderly patients (Patrick, Gohman, Marx, Delegge & Greenberg, 1998). Both guar gum and ispaghyla, but not microcrystalline cellulose produced gastrointestinal symptoms (Bianchi & Capurso, 2002). Inulin (Davidson & Maki, 1999; Pedersen et al, 1997) and fructo-oligosaccharides (Briet, Achour, Flourie, Beaugerie, Pellier, Franshisseur, Bornet & Rambaud, 1995; Stone-Dorshow & Levitt, 1987) may contribute to bloating, flatulence and diarrhea. Bloating and flatulence have also been observed with the consumption of resistant starch (Heijnen et al, 1998). Psyllium may pose a risk of esophageal obstruction (Noble & Grannis, 1984) and small bowel obstruction and may have adverse effects on colorectal adenoma recurrence (Bonithon-Kopp, Kronborg, Giacosa, Räth & Faive, 2000), and the risk of anaphylaxis (Drake, Moses & Tandberg, 1991; James, Cooke, Barnett & Samson, 1991; Lantner, Espiritu, Zumerick & Tobin, 1990).

2.4 Dysphagia

Dysphagia encompasses a wide variety of swallowing disorders that result from congenital abnormalities and acquired neurological disease or injury. Diseases such as multiple sclerosis, cerebral palsy, Parkinson's disease, Alzheimer's disease and cancer and its treatment can result in dysphagia, as can spinal cord injuries, head trauma and stroke (ADA, 2000). Many medications such as anti-Parkinson's disease drugs, neuroleptics and anticholinergics can lead to dysphagia and others can contribute to dysphagia by causing symptoms such as dry mouth (ADA, 2000). Dysphagia may also result from the process of aging (Feinberg, Knebl, Tulley & Segall, 1990).

The normal swallow consists of the oral-preparatory, oral-transit, pharyngeal-transit and esophageal-transit phases (ADA, 2000). Problems with the oral-preparatory phase include reduced cheek and lip tone, decreased lip closure, poor or reduced tongue control and reduced oral sensation or awareness. Dry mouth and inflammation of the oral cavity can also contribute to problems in the oral-preparatory phase. The oral-transit phase may demonstrate delayed, absent or an uncontrolled swallowing reflex. During the pharyngeal-transit phase, there may be reduced laryngeal closure or elevation, or both. Finally, a weak upper esophageal sphincter, reduced esophageal peristalsis and esophageal obstruction produce problems in the esophageal-transit phase.

Deficits in the oral-preparatory or oral-transit phase, or both, result in poor bolus formation may lead to aspiration (Logemann, 1988). Delays in esophageal transit may result in regurgitation of food material and spilling into the airway, or food remaining in the esophagus. Clinical manifestations of swallowing disorders include: coughing, absence of gag reflex, gargling voice quality, recent history of pneumonia, inability to manage secretions resulting in drooling, pocketing of particulate food matter inside the cheeks or under the tongue, regurgitation of food, delayed or slow swallow reflex, and very slow eating (Steingold & Vartan, 1991).

Dysphagia poses serious health risks, with choking and aspiration (misdirection of food or liquids into the larnyx) of food and liquids being paramount. The aspiration of food particles can obstruct the airway, or food particles that remain in the airway may contribute to a bacterial infection. Aspiration of food is associated with an increased incidence of aspiration pneumonia (Loughlin, 1989). The food source aspirated and the amount aspirated are important factors in the development of aspiration pneumonia (Langmore, 1991). For example, the aspiration of clear liquids does not pose significant risk unless the liquid is acidic (Effros, Hogan, Wahlen-Hoagland, Olson & Lin, 2001). Difficulty with swallowing and the resulting fear of aspiration and choking can lead to decreased oral intake, which may lead to dehydration, weight loss and malnutrition (ADA, 2000). Malnutrition is positively associated with dysphagia (Keller, 1993).

Although aspiration of liquids and food particles is often cited as an important cause of aspiration pneumonia, aspiration of refluxed gastric contents is a more serious cause. The reflux of gastric contents increases when individuals lie down immediately following food or liquid intake, and occurs in both dysphagic and non-dysphagic individuals (Feinberg, 1990). Further, the aspiration of oral secretions containing pathogenic Gram-negative bacteria is a definite risk for aspiration pneumonia (Preston, Gosney, Noon & Martin, 1999; Shay, 2002).

2.4.1 Dysphagia in the Institutionalized Elderly

Three in four older adults in long term care facilities may experience dysphagia symptoms while eating (Sonies, 1999; Steele, Greenwood, Ens, Robertson & Seidman-Carlson, 1997). Reports of the prevalence of dysphagia may vary with the criteria used for diagnosis, and there may be significant under-diagnosis (Steingold & Vartan, 1991). In addition, dysphagia can improve or worsen with the course of disease or condition. The predictors of aspiration of pneumonia of hospitalized or institutionalized elderly are feeding dependence, oral care dependence, decayed teeth, tube feeding, co-morbidities, number of medications prescribed and smoking (Langmore, Terpenning, Schork, Chen, Murray, Lopatin & Loesche, 1998).

2.4.2 Dysphagia Management

The goal of dysphagia management is to maximize food intake and minimize the risks associated with swallowing. There are a number of factors that influence the risk of choking and aspiration in a dysphagic individual while eating, such as physical position of eating, utensil used and use of cues (Williams & Walker, 1992). With normal swallowing, an individual is able to adjust to changes in the viscosity, consistency, volume, mass and temperature of foods. Simmons (1986) explains that temperature, pH, volume offered, and size and shape of particulate matter all affect the likelihood of a food bolus passing safely through the swallowing process in dysphagic individuals. Strong flavours are recommended to stimulate swallowing and mastication and bland foods are to be avoided (Martin, 1991). With most types of swallowing disorders, the textural characteristics of the food, including viscosity, consistency and homogeneity, become critical to successful swallowing (ADA, 2000).

2.5 The Dysphagia Diet

Although dysphagia results from a plethora of problems in one or more phases of the swallow, food textures that are most often indicated for the management of dysphagia are described as moist, semi-solid consistencies that form a cohesive bolus, with the avoidance of foods with more than one consistency (ADA, 2000). Pureed diets are recommended for individuals with oral motor deficits, pharyngeal weakness and poor airway protection (ADA, 2000). However, pureed diets may be ordered for long term care residents for behavioral problems and feeding convenience (Cluskey, 1989a), as well as psychological reasons (Cluskey, 1989b). A pureed diet is offered to 14-26% of long term care residents (Hotaling, 1992; Cormier, Harper, O'Hara, Brillant, Caissie, Dubeau & Mitalas, 1994) and these residents tend to be older women with dementia, and are less likely to have suffered a cerebral vascular accident than the total long term care population (Cormier, 1994). Curran and Groher (1990) found that residents of long term care consuming institutionally-prepared pureed foods had significantly more aspiration pneumonia than did those residents consuming soft mechanical textures.

2.5.1 Descriptive Recommendations for the Preparation of Pureed Foods

Dietary management strategies for many dysphagic conditions recommend moist, semi-solid foods that can maintain a cohesive bolus (ADA, 2000). Current therapeutic diet standards have responded to this requirement with recommendations that pureed food should have a spoon-thick or pudding-like consistency, be thick and homogenous, and have no coarse textures (ADA, 2000). The Level 1: Dysphagia Pureed of the National Dysphagic Diet Task Force indicates that any foods requiring bolus formation, controlled manipulation and/or mastication are excluded (ADA, 2002).

Descriptive recommendations for pureed food are abundant in the literature (Mayes, 1985; Martin, 1991; Penman & Thomson, 1998; UK Department of Health, 1995; Martin & Backhouse, 1993; ADA, 2000, ADA, 2002). The ideal pureed consistency should resemble whipped topping or squash (Mayes, 1985). Penman and Thomson (1998) describe a thin puree as one with a homogenous consistency which does not hold its shape after serving, and a thick puree which as one which is smooth, soft and holds its shape after serving and when swallowed. The United Kingdom Department of Health (1995) defines a puree as a consistency without lumps or stringy bits. The puree should drip rather than pour from a spoon. Martin and Backhouse (1993) describe a smooth and thick texture puree as one that should hold a mould, be moist, form a bolus with no chewing, have no lumps but may have small texture variations. Martin (1991) states that a dysphagia diet should consist of thick, smooth, semi-liquid textures. Curran and Groher (1990) describe pureed food as a thinned, blenderized food, and outline a dysphagic aspiration risk reduction diet that is more appropriate for oral-pharyngeal dysphagia. Descriptions of the pureed texture may be useful for the preparation of pureed foods, but are subject to interpretation and may lack the reproducibility that is required for safe pureed food production and dysphagia management.

2.5.2 Textural Properties Important to Dysphagia Management

Food texture is defined as "that group of textural characteristics that arise from the structural elements of the food, are sensed primarily by the feeling of touch, are related to deformation, disintegration and flow of the food under a force, and are measured objectively by functions of mass, time and distance" (Borne, 2002). Current therapeutic diet standards suggest that there are a number of textural characteristics such as thickness, smoothness, homogeneity and consistency, that are necessary for the successful management of dysphagia (ADA, 2000). Of the textural characteristics identified as most significant in dysphagia management by the U.S. National Dysphagic Task Force (ADA, 2002), pureed foods possess viscosity, cohesiveness, adhesiveness, hardness and yield stress. The size of particulate matter is another textural characteristic that influences swallowing (Ordre des diététistes du Québec, 2000).

2.5.2.1 Viscosity

Viscosity is a characteristic of liquid and semi-liquid foods and is defined as the "rate of flow per unit force" or "as the internal friction of a liquid or its resistance to flow" (Szczesneak, 1962). This friction becomes apparent when one layer of liquid is forced to move against another layer. As friction increases, greater force, known as shear, is required to maintain flow (Brookfield Engineering Inc, 2003). Shear occurs whenever a liquid or semi-liquid is moved, and thus occurs during the human swallow. Viscosity (η) may be mathematically defined by the formula:

$$\eta = \frac{\tau}{\gamma}$$

Shear stress (τ) is defined as the force per unit area required to produce the shearing action. Shear rate (γ) is defined as a velocity gradient, a "measure of the change in speed at which the intermediate layers move with respect to each other" (Brookfield Engineering Inc, 2003). Shear rate is measured in units of reciprocal seconds (sec^{-1}).

Viscosity is measured in units of poise. A material requiring a shear stress of one dyne per square centimeter has a viscosity of one poise, or 100 centipoise (Brookfield Engineering Inc, 2003). Alternatively, viscosity can be expressed in SI units, with one Pascal-second equal to ten poise and one milli-Pascal-second is equal to one centipoise (Brookfield Engineering Inc, 2003).

Fluids are classified as Newtonian and non-Newtonian fluids. Newtonian fluids are those which at a constant temperature give a constant viscosity measurement which is independent of shear rate. Newtonian liquids will give the same viscosity measurement with all models of viscometers and apparatus used. Non-Newtonian fluids are those in which the relationship τ/γ is not constant, thus measured viscosity will change with changes in shear rate. Therefore, viscosity measured in non-Newtonian fluids is called apparent viscosity (Brookfield Engineering Inc, 2003). Non-Newtonian fluids can be pseudoplastic (decreasing viscosity with an increase in shear rate) or dilatant (increasing viscosity with an increase in shear rate). Non-Newtonian fluids can also be plastic in which a certain amount of force (yield stress) must be exerted onto the fluid before flow begins (Brookfield Engineering Inc, 2003). The apparent viscosity of non-Newtonian fluids may also vary with time (Borne, 2002). Thixotropic fluids show decreases in viscosity with time when a constant shear rate is applied and rheopexic fluids demonstrate an increase in viscosity with constant shear rate (Borne, 2002). The viscosity of most fluids is affected by temperature, with most fluids becoming less viscous with increases in temperature (Borne, 2002). Finally, the viscosity of multiphase systems, such as emulsions and dispersions, is influenced by the size, shape and interactions of the particulate material (Brookfield Engineering Inc, 2003).

Viscosity is a textural characteristic manipulated in many foods for stability and sensory purposes and is measured by a number of methods, including the Brookfield viscometer and cone-plate viscometer (Borne, 2002). The Brookfield viscometer has been used to measure viscosity in a variety of food systems (Borne, 2002), although no known research has been conducted on the suitability of these methods for the analysis of dysphagic pureed food.

It has been suggested that the line spread test could be used as a fast and reliable method of determining the viscosity of pureed foods and thickened beverages for the dysphagic diet (Mann & Wong, 1996). The line spread test requires a plastic sheet on which is printed as series of concentric circles with a stainless steel cylinder of a known volume. A known volume of food to be measured is placed in the cylinder, the cylinder is lifted from the plastic sheet, and the food is allowed to disperse on the plastic sheet for thirty seconds. The average distance the food travels is determined. However, this method has been validated using sensory data only (Mann & Wong, 1996) and not with objective viscometric data.

Viscosity is the mechanical characteristic that most influences oral-pharyngeal-transit time (ADA, 2000). It is has been shown that oral-transit and oral-pharyngeal-transit is delayed with more viscous foods (Dantas & Dobbs, 1990). Aspiration is significantly decreased when foods have slower oral-pharyngeal transit time, as the person with dysphagia is better able to control mastication, transport and swallow (Williams & Walker, 1992). Increased viscosity of a food bolus has been shown to prolong peristaltic contractive waves and the speed of propagation of the bolus into the esophagus (Dooly, Scholossmacher & Valenzuela, 1988). Other researchers have not confirmed this finding (Ergun, Kahrilas & Logemann, 1993; Kim, Hsu, O'Conner, Weaver, Brown & Zinmeister, 1994). As liquids require greater oral coordination and fine motor control than do solids, the use of liquids thickened to a puree consistency is recommended for patients suffering from pharyngeal dysfunction (Lazarus, Logemann, Rademaker, Kahrilas, Pajak, Lazar & Halper, 1993). However, viscosity is also related to the tongue force required during the swallow, with increases in viscosity requiring increased force (Pouderoux & Kahrilas, 1995). Pureed foods with high viscosities may become difficult to swallow due to the increased muscular effort required. Raut (2001) states that "medium-thick liquid boluses are the favored consistency, as they tend to alter the pharyngeal response to protect the larynx, a compromise between excessive viscosity and the tendency of thin liquids boluses to penetrate the larynx".

2.5.2.2 Consistency

Consistency is closely related to viscosity, although other textural characteristics such as surface tension influence consistency determinations (Borne, 2002). The Bostwick Consistometer is commonly used to assess the consistency of fruit and vegetable purees such as applesauce, baby foods and tomato catsup (Borne, 2002). A compartment of the Bostwick Consistometer is filled with the pureed food to be tested and leveled. A trigger is pressed, releasing the gate and allowing the food to flow into the second compartment. The distance in cm traveled in thirty seconds is determined. Rutgers (1958) indicated that the consistometer is suitable for porridge and purees that were non-thixotropic (the property of various gels of becoming fluid when disturbed), but not for starch-thickened milk puddings.

2.5.2.3 Cohesiveness

Cohesiveness, which is the "strength of internal bonds making up the body of the product" (Szczesneak, 1963), is also indicated as a significant textural characteristic necessary for successful dysphagia management (ADA, 2000). Cohesiveness can be determined by the Texture Profile Analysis (TPA) method (Borne, 1982). Oral control may be better with cohesive foods and lack of cohesiveness can result in fractionation of the food bolus leading to choking or aspiration. Prinz and Lucas (1997) suggest that the forces binding food particles together (the viscous cohesion of the bolus) initiate swallowing, and that it is the cohesiveness that prevents the inhalation of small particles of food into the respiratory tract.

2.5.2.4 Adhesiveness

Adhesiveness, is the "work (force in grams) necessary to overcome the attractive forces between the surface of the food and the surface of other materials with which the food comes in contact such as the tongue, teeth and palate" (Szczesneak, 1963) and can be objectively determined with the Texture Profile Analysis (TPA) method (Borne, 1982). Adhesiveness may influence the swallow and excessive adhesiveness may lead to delayed swallowing. Curran and Groher (1990) suggest that sticky foods, such as white bread and mashed potatoes, are contraindicated for oropharyngeal disorders as these foods require increased effort to move the food through the swallow. Martin (1991) comments that sticky foods, such as peanut butter or melted cheese, should not offered in a pureed diet. Current dysphagic diet standards recommend the avoidance of sticky foods (ADA, 2000).

2.5.2.5 Particle Size

Particle size may be critical in dysphagia management as larger particles may cause immediate choking (Finestone, Fisher, Greene-Finestone, Teasell & Craig, 1998). Food particles can be pocketed or squirreled in the cheek or under the tongue and may remain there until the end of the day (Kumlien & Axelsson, 2002). This may pose a risk for later aspiration or choking. Larger particles of food simply prevent the formation of a cohesive bolus for safe swallowing. Mayes (1985) suggests that pureed food should not be grainy.

Particle size of pureed foods has been suggested not to exceed 1mm or 1000 μm. (Ordre des diététistes du Québec, 2000). As the mastication of food is a combination of the breakdown of solid foods to smaller particles and the incorporation of saliva, pureed foods, intended for dysphagic individuals with little or no ability to masticate, should possess characteristics of food ready to be swallowed. Using healthy subjects, Hoebler, Deveux, Karinthi, Belleville and Barry (2000) evaluated bread and pasta after mastication. Masticated bread gave a bimodal distribution with peaks at 30 μm and 500 μm, and pasta gave larger particle sizes, peaking at 500 μm and 300 mm. Prinz and Lucas (1995) suggest that a bolus (yogurt/nut mixture) with particles of less than 1400 μm may be appropriate texture for swallowing. Jiffrey and Molligoda (1983) found that soybeans, masticated by healthy dentated individuals, produced particles less than 1180 μm prior to swallowing. Particles averaging 2400 μm were broken down most rapidly, and particles averaging 655 μm were formed quickly. Jiffry (1981) evaluated the mastication of foods using normal dentate subjects and found particles of food ranging from 53 to 4750 μm with modes of 600 μm and 1200 μm. In a later study, Jiffry (1983) found that denture wearers and mixed-dentition individuals prepared boluses with particles with modes of 2000 and 4000 μm, respectively. This research suggests that a range of particle sizes can lead to an initiation of a swallow in normal subjects, but that particles much larger that 1000 μm may initiate a need to masticate. It is possible that in certain institutionalized individuals, the need to masticate and the lack of ability to masticate larger particles may result in a delay or refusal to swallow. As the liquids used in the preparation of pureed foods differ from their saliva in their composition and ability to promote a cohesive bolus, it is possible that a smaller average particle size is required in pureed foods to maintain a smooth, cohesive bolus. In addition, as many individuals with dementia as well as dysphagia may hold food particles in their mouths, the risk of later aspiration and choking must be minimized through a reduction in particle size.

2.5.2.6 Moisture Content and Phase Separation

The incorporation of moisture into foods is important to swallowing and, therefore, an important characteristic of pureed foods. In normal mastication, saliva functions to lubricate food particles to promote a cohesive bolus (Prinz & Lucas, 1997). A study on the mastication of meat demonstrated that a significant incorporation of saliva occurs prior to the swallow (Mioche, Bourdiol & Monier, 2003). For example, lean beef (originally 60% moisture), when masticated, increased in weight by 30-36%, giving a bolus of about 70% moisture. Mastication of bread and spaghetti showed an incorporation of saliva of 20% and about 4% respectively (Hoebler et al, 1998), producing a bread bolus of 57% moisture and a pasta bolus of 76%. Prinz and Lucas (1995), using a suspension of nuts in yogurt, found a lubrication threshold of about 69% water. Insufficient saliva production has been shown to increase perceived swallowing problems (Logemann, Smith, Pauloski, Rademaker, Lazarus, Colangelo, Mittal, MacCraken, Gaziano, Stachowiak & Newman, 2001) and oral dryness can lead to the particles remaining in the oral cavity instead of being transported back for swallowing (Liedberg & Owall, 1991). If swallowing is delayed, excess saliva can cause problems by reducing cohesion of the bolus (Prinz & Lucas, 1997). It is likely that insufficient moisture content of pureed food may delay swallowing and excess water in pureed foods will result in a watery bolus that lacks cohesion and is difficult to swallow, particularly in dysphagic individuals.

Monophasic foods are recommended for dysphagic management, as foods with both a solid and a liquid phase are difficult to control in the oral phase of the swallow. Examples of a two-phase system are vegetable soup and cold cereal and milk. Liquid and solid phase separation may occur in semi-solid food systems such as pureed foods. Steingold and Vartan (1991) suggest that when food is pureed in a typical institutional manner, water may separate from the particulate matter, leading to a two-phase food system. Syneresis, the phase separation of pureed food systems, may lead to aspiration of liquids or of particulate solids that may be held in the mouth. Williams and Walker (1992) confirmed that if liquid was added during pureeing, this liquid may separate out, thereby increasing the risk of aspiration. Syneresis is influenced by the percentage of water, particle size and the presence of starch or stabilizers (Nelson, 2001). Penman and Thomson (1998) recommended that purees not separate into liquid and solid phases. The United Kingdom Department of Health (1995) also emphasizes that there should not be any separated liquid. The ADA (2000) indicated that dysphagic diets should exclude foods with more than one consistency.

2.6 High Fibre Ingredients

Fibre ingredients exhibit a number of food functions and applications. In baked products, fibre ingredients increase water absorption, influence crumb texture and tenderness, and may also influence colour and flavour (Nelson, 2001). In beverage and dairy products, fibre ingredients function to increase total fibre content, influence mouthfeel (Martinou-Voulasiki & Zerfiridis, 1990), stabilize the food system (Hassan, Helmy & Enab, 1999; Martinou-Voulasiki & Zerfiridis, 1990) and influence flavour. Fibre ingredients also have various applications in confectionery goods, meat, poultry, seafood and analogs, and in soups, sauces and salad dressings (Nelson, 2001).

2.6.1 Types of High Fibre Ingredients

Wheat bran was the first and has been the most utilized of high fibre ingredients added to foods to increase total fibre. Fibre ingredients from cereals, legumes, fruits and various other plants are processed and concentrated using both mechanical and chemical means, produce high fibre ingredients with its unique chemistry and functional characteristics. In Canada, novel fibre is defined as fibre that traditionally has not been used for human consumption, that has been chemically processed, oxidized or physically processed, or that has been highly concentrated from its plant source (Health Canada, 1996). Novel fibre sources may not be calculated and declared in nutrition labeling table of a food unless proof of efficacy as fibre in the same type of food has been shown through clinical testing to the satisfaction of the Health Protection Branch and a letter of no objection has been issued (Health Canada, 1996). Fibre sources currently approved for food use in Canada include apple pomace, corn bran, mustard bran, oat bran, oat hull, pea hull, psyllium seed husk, rice bran, soy cotyledon, sugar beet fibre, coarse, medium, fine and starch reduced wheat bran and traditionally milled cereals, legumes, nuts and seeds. Fibres approved as food ingredients, although not considered novel fibre sources include pectin, carrageenan, guar gum, methylcellulose, carboxymethyl cellulose, microcrystalline cellulose, inulin, powdered cellulose and ß-glucan from barley and oat.

2.6.1.1 Viscous Fibre Ingredients

Viscous fibre ingredients produce high viscosities and water-binding at low concentrations and create gelation in food systems (Nelson, 2001). Gums are highly viscous fibres that are plant or algae derived and include guar gum, gum arabic, alginate, locust bean gum and carrageenan. Gums, also know as hydrocolloids, function to stabilize food systems due to their ability to bind water by forming a three-dimensional network of hydrated molecules (Neilsen, 1984). Gums are water soluble, water dispersible and have substantial thickening and gelling capacity. Locust bean gum, guar gum, carrageenan, pectin and inulin are used as stabilizers in yogurt, pudding and ice cream products, and function to decrease syneresis and improve texture (Kailasapaty & Sellapan, 1998; Nelson, 2001).

Xanthan gum is an example of a highly viscous, soluble fibre ingredient. It is a bacterial polysaccharide produced by fermentation of Xanthomonas campersteris that is used widely in food applications (Cottrell & Kang, 1978). Xanthan gum is a high molecular weight polysaccharide that is composed of repeating units of glucose, mannose and glucuronic acid. It is a hydrocolloid that is characterized by high viscosity, high pseudoplasticity, heat, pH stability and high solubility, and is compatible with various salts. Xanthan gum, combined with a galactomannan, such as locust bean gum or guar gum, produces synergistic increases in viscosity. In food systems, xanthan gum is used as a stabilizer and thickener in salad dressings, bakery fillings, dairy products, sauces and frozen and canned products. It provides excellent stability during refrigeration as well as freeze-thaw stability, particularly in starch-thickened systems (Cottrell & Kang, 1978). The ability of xanthan gum to provide relatively constant viscosity over a wide range of temperatures for long periods of time is important for institutional use. Xanthan gum has been shown to be effective in preventing drip losses or water separation in frozen and thawed, cooked pureed vegetables (Downey, 2002).

Soy cotyledon fibre is an example of a moderately viscous, soluble fibre ingredient. Soybean cotyledon fibre, such as Fibrin® (Protein Technologies International, St; Louis, MO) is derived from dehulled and defatted soybean flakes and is comprised of the cell wall material of the soybean cotyledon, and consists of mostly non-cellulosic residues, D-galacturonic acid, D-galactose, rhamnose, arabinose, xylose and fucose (Lo, 1989). With a total fibre content near 80%, soybean cotyledon fibre is used in bread and cereal products to increase fibre content and in liquid or semi-liquid systems to reduce syneresis and stabilize food systems.

2.6.1.2 Low Viscosity Fibre Ingredients

Low viscosity insoluble fibre ingredients include processed wheat bran, oat hull fibre, corn bran fibre and pea hull fibre, among others. The addition of low viscosity fibres is often used to increase the total fibre content of food systems. Foods incorporating low viscosity insoluble fibre ingredients include baked products and breakfast cereals. Pea hull fibre is the flour resulting from the processing of the hull of the common yellow field pea. Pea hull fibre, depending on processing method, is 75-90 % fibre of which 95% is insoluble.

Microcrystalline cellulose is another example of a low-viscosity, insoluble fibre. It is a purified, non-viscous fibre ingredient that results from controlled hydrolysis of α-cellulose (McCormick, 1985). It is insoluble in water, but will disperse to form an opaque gel. Microcrystalline cellulose is often used in combination with a gum for stability and to retard melting of frozen foods such as ice cream (Igloe, 1982).

2.6.2 High Fibre Ingredients and Pureed Foods

The ability of semi-solid, pureed foods to bind water is important to food aesthetics (Nelson, 2001), but is also critical to dysphagia management (ADA, 2000). Oral control by most dysphagic individuals requires a homogeneous food system (ADA, 2000) versus a two phase system. The size, composition and water holding capacity of particulate matter influences phase separation, as well as the composition, function and concentration of the fibre ingredients (Nelson, 2001). Pureed food products with poor freeze-thaw stability and syneresis, due to poor water-holding ability, may be remedied by adding low levels of viscous, fibre ingredients. The requirement of a pureed food system to be monophasic, smooth, cohesive and thick may be achieved by the addition of fibre ingredients. Functional and sensory testing is required to ensure that the ideal fibre ingredient is used in the production of pureed foods.

2.6.3 Quality Concerns with Fibre Ingredients

The addition of fibre ingredients may cause product quality problems in food systems. The use of guar is limited in some products because of its off-flavour, but reduced-odour guar gum has been developed (Ward, 1999). Too much mouth cling can occur in certain food products with added high fibre ingredients, but can be decreased with a reduction in fibre particle size (Nelson, 2001). High levels of viscous high fibre ingredients may result in a gummy, adhesive product (Nelson, 2001). The particle size of the low-viscosity fibre ingredient is critical, as a gritty mouth feel can result with larger particle sizes and may be a factor in the limited application of these types of fibre in semi-solid food systems (Nelson, 2001). However, viscous fibre ingredients may improve the mouth feel and body of a semi-solid food product, and may even eliminate the gritty mouth feel of a low viscosity, insoluble fibre ingredients at increased viscosities (Nelson, 2001).

The addition of high fibre ingredients, particularly hydrocolloids such as guar gum and carboxymethyl cellulose, can decrease sweetness or flavour (Mälkki, Heeiniö & Autio, 1993), but this can be offset by increasing the level of a sweetener or by using alternate sweetener and flavouring agents (Demirag, Elmaci & Altug, 1999). Fibre ingredients that thicken to a pseudoplastic consistency may have less influence on flavour than do gelling substances, as slight increases in gel rigidity can substantially alter the perceived taste and flavour (Mälkki et al, 1993).

2.7 Sensory Evaluation of Food

Sensory evaluation can be defined as "the scientific discipline used to evoke, measure, analyze and interpret those reactions to characteristics of foods and materials as perceived through the senses of sight, smell, taste, touch and hearing" (Poste, Mackie, Butler & Larmond, 1991). The three basic types of sensory analysis methods are discriminative, descriptive and affective tests. Discriminative testing is used to determine if there is a difference between samples (Poste et al, 1991). A common discriminative test is the triangle test in which sensory panelists are asked to select the one different sample among three, where two are the same. Descriptive testing is used to identify and describe sensory characteristics of a food, such as taste or texture (Poste et al, 1991). Flavour profiling is an example of descriptive testing. Finally, affective testing evaluates preference, liking or acceptance of a food.

There are a number of factors that influence sensory evaluation including physical facilities, sample preparation, selection and training of panelists, experimental design and sensory analysis methods (Poste et al, 1991). The sensory evaluation area should be kept constant for all tests and should be free of distractions. Temperature should be controlled and the surroundings should be quiet. To keep responses independent, panelists should be separated by partitions. A method of communication between researcher and panelists needs to be developed. Food preparation and sensory evaluation are best conducted in separate rooms to limit the influences of cooking odours.

Poste (1991) outline the following recommendations for sample preparation. Sample preparation including cooking, freezing, reheating, equipment and utensils used must be standardized to reduce bias. Samples should be served at the temperature at which the food is normally consumed, if the purpose of the sensory panel is affective evaluation. However, if the purpose of the investigation is descriptive or discriminative, then a temperature between 20°C and 40°C may be appropriate. The amount of sample provided should be constant and sufficient for the panelist to taste and re-taste if necessary. It is recommended that discriminative testing should provide samples of at least 28 g. The number of samples to be evaluated should be limited, so as to not create sensory or mental fatigue in the panelist. Coding of the samples should not give any hints to the panelists.

Poste et al (1991) suggest factors that are important to the selection of panelists. Panelists selected should be non-smokers with good oral health. In addition, panelists with allergies and dislikes to the foods tested should not participate. The interest, availability and punctuality of panelists are important. Panelists may be screened by their ability to detect differences in foods. For example, if samples are thought to differ in their level of bitterness and this is the characteristic of interest, only those panelists who have the genetic ability to detect certain bitter components may be used in the panel. Volunteers identified, as having poor physical health, should not be used as sensory panelists, as their ability to taste may be reduced or altered.

Standard procedures should be carried out to avoid the psychological errors that may arise in evaluation (Poste et al, 1991). The use of random, three-digit coding of samples helps to prevent expectation error, preventing panelists from expecting samples label "A" or "1" to be best. Producing samples to appear as similar as possible will help to prevent stimulus error, as irrelevant differences between samples may influence the results. It is recommended that panelists evaluate only one characteristic at a time to reduce the possible halo effects, i.e. one characteristic influencing the results for a different characteristic. The reactions of co-panelists may influence results and thus panelists should be separated by partitions in an area free from noise and distraction. Panelists should not be permitted to talk during the evaluation session. Positional, convergence and contrast bias can be eliminated by presenting samples in a random order.

2.8 Sensory Changes in the Elderly

The acuity of taste and smell in the elderly may be diminished (Schiffman & Pasternak, 1979; Shiffman, 1987), particularly in the sick elderly (Schiffman, 1983). Sweeter foods have been found to be more pleasant to elderly individuals (de Jong, de Graaf & van Severen, 1996). It has been shown that flavour enhancement of foods for the elderly results in improved food intake, biochemical indices and anthropometric indices (Schiffman & Warwick, 1993). Although there is some evidence regarding taste and odour acuity changes with age, sensory changes may not result in changes in food choice or dietary behaviour (Drewnowski, Hendersen, Driscoll & Ross, 1996).

2.9 Summary

As the total fibre intakes of individuals residing in long term care may be marginal, fortification of institutional foods with functional, insoluble fibre ingredients offers a possible way of ensuring that these individuals will meet current fibre recommendations and, thereby, preventing constipation. The fortification of institutional diets must span both regular and texture-modified diet consistencies, allowing all residents of long term care to achieve their fibre requirements. Fibre-fortified pureed food must maintain a monophasic, smooth, cohesive, pudding-like and spoon-thick consistency for successful dysphagic management and the fibre ingredients selected may function to achieve these recommended textural characteristics. The acceptability and effectiveness of fibre-fortified regular and texture-modified institutional food requires investigation.

3. OVERVIEW OF RESEARCH

The studies described in this thesis were carried out to determine the efficacy and potential effectiveness of fortification of long term care diets with a functional fibre source, pea hull fibre. The fortification of foods with fibre, particularly for the institutionalized population, is complex. Texture, taste and general acceptability of fibre-fortified foods must be ensured. The purpose of this chapter is to provide an overview of the thesis research and thereby provide an understanding of the complexities of the various research initiatives that were undertaken to evaluate the fibre fortification of long term care diets.

3.1 Fibre Fortification of Institutional Foods

The use of pharmaceutical laxatives, particularly the polypharmacy of laxatives that is observed in long term care facilities (Glia & Lindberg, 1997), poses undue risk to the long term care residents when dietary fibre is a safe alternative. A recent study of long term care facilities in Saskatchewan found that the level of dietary fibre offered to elderly residents was below the recommended level (Lengyel, 2002). Offering diets containing inadequate levels of dietary fibre, and the resulting constipation, exacerbates care needs and decreases the quality of life of the elderly residents (Glia & Lindberg, 1997). Fibre fortification of foods offered to residents of long term care facilities, particularly the elderly, may provide a practical way of improving their health and well being. However, sustaining an increase in the dietary fibre content of long term care diets by adding or adjusting one food item has been unsuccessful (Clark & Scott, 1976; Hankey et al, 1993). An alternative approach would be to add small amounts of fibre to a number of food items. The finely ground hull of the common yellow pea may be a suitable fibre source for inclusion in foods offered in long term care facilities. Commercial pea hull fibre contains 78-90% of total fibre, with the majority being insoluble, and, therefore, should provide significant fecal bulking capacity. In addition, the fine particle size of commercial pea hull fibre (<100 μm) may make it ideally suited for incorporation into a variety of foods served in long term care facilities.

3.2 The Effect of Finely Processed Pea Hull Fibre on Laxative Use, Bowel Function and Food Acceptance in Long term Care Residents.

Chapter 4 describes a study on the effect of finely processed pea hull fibre on laxative use, bowel function and food acceptance in long term care residents. It was hypothesized that the dietary fibre intake of elderly residents could be increased by incorporating pea hull fibre into multiple cooked or baked foods, with no decrease in food acceptance, and thereby improving bowel habits and reducing laxative use. An increase in fibre intake of 5 g/day over the current estimated intake of about 10 g/day was projected as being necessary to achieve improved bowel evacuation in elderly constipated patients. The study was designed to be an intervention carried out in a fully operational long term care facility. To determine if a moderate increase in the level of fibre in foods consumed by institutionalized individuals would increase bowel movement frequency, data were collected on the same individuals (n=114) both before and during a six-week intervention in which finely processed pea hull fibre (1-3 g/serving) was added to three or four foods each day. Laxative and enema use were monitored. The addition of a moderate amount of pea hull fibre to foods resulted in no change in food acceptance and increased bowel frequency in institutionalized individuals. Baked goods and other cereal-containing foods were the most common vehicles for fibre fortification.

3.3 Sensory and Textural Evaluation of Baked Goods Fortified with Pea Hull Fibre

Chapter 5 describes the sensory and textural evaluation of baked goods fortified with pea hull fibre. Although food wastage in the intervention trial, described in the previous section, did not change, and there was evidence of acceptance of foods fortified with pea hull fibre, sensory and textural evaluation of baked products containing pea hull fibre sources was undertaken. The objectives of this study were to evaluate the effect of pea hull fibre on the textural and sensory characteristics of baked products. The textural characteristics and physical characteristics, e.g. loaf volume, of cookies, cake, muffins and bread fortified with pea hull fibre were evaluated, as was the sensory acceptability of cookies and cake. The results of this study indicated that the addition of pea hull fibre to baked products requires additional water to maintain loaf volume, and resulted in significant changes in the textural and sensory characteristics of cookies, cake and bread. The addition of pea hull fibre generally resulted in a softer product, but decreased the sensory acceptability of cookies and cake. However, most products remained acceptable.

3.4 Preparation of Grain-based Pureed Foods in Long term Facilities and Their Intake by Dysphagic Long term Care Residents

Chapter 6 describes a study on the preparation of grain-based pureed foods for dysphagic individuals and the intake of grain-based pureed foods by long term care residents consuming pureed foods. Many long term care residents with dysphagia require pureed foods. Although grain products, such as slurried breads and pureed pastas, are indicated for use in the pureed diet, it is not known if these foods are commonly prepared for dysphagic individuals. As breads, pastas and cereals were the foods most easily fortified with pea hull fibre, dysphagic residents may not receive the full benefit of fibre fortification if their intakes of breads and cereals are low. The objectives of this study were to determine the extent of preparation of grain-based pureed foods in Saskatchewan long term care facilities, and to determine the intakes of grain-based pureed foods and the average fibre intakes of dysphagic long term care residents receiving pureed foods. A fax-back survey of seventy-nine, long term care facilities was carried out to determine the extent of grain-based pureed food preparation in Saskatchewan long term care facilities. Weighed food intakes of meal time pureed foods were carried out (n=20). The results of the survey indicated that pureed pastas, rice, baked products and slurried breads were never or rarely (< once a week) prepared in Saskatchewan long term care facilities. Potatoes were commonly offered. The fibre intake by dysphagic individuals consuming pureed foods was found to be inadequate. These residents would receive limited benefit from fibre fortification of the long term care menu through cereal-based products.

3.5 Textural Characteristics of Pureed Foods

Chapter 7 describes a study on the textural characteristics of pureed foods. The textural qualities of pureed foods are critical to dysphagia management, and objective methods for textural analysis are needed to ensure standardized, institutional pureed food production, with and without fibre fortification. The objectives of this study were to assess the validity of the Bostwick Consistometer, the line spread test and a spoon-thickness test for the prediction of viscosity, to determine the suitability of the wet sieve method of particle size analysis for pureed foods and to determine if objective measurements of hardness, cohesiveness and adhesiveness were suitable for the evaluation of a wide variety of puree-consistency foods. Institutional pureed foods, commercial puddings and pureed foods, and baby foods were analyzed for viscosity, consistency, hardness, cohesiveness, adhesiveness and particle size. The textural characteristics of commercial pureed foods differed from those of institutional pureed foods, having finer particle sizes and viscosities significantly closer to the recommended pudding standard. Consistency, as determined by the Bostwick Consistometer and line spread test, proved to be poor predictors of apparent viscosity, whereas the spoon-thickness test proved to be a better predictor. The results of this investigation were used to outline target viscosity and other textural characteristics for fibre-fortified pureed foods.

3.6 Development and Characterization of Pureed Foods Fortified with Pea Hull Fibre

Chapter 8 describes the development and characterization of pureed foods fortified with pea hull fibre. As the fibre intakes of dysphagic individuals were found to be inadequate, fortification of pureed foods offers a way of ensuring that dysphagic individuals will meet fibre intake recommendations, thereby avoiding constipation. In addition, the requirement for pureed foods to have a pudding-like and spoon-thick consistency for successful dysphagic management may also be achieved by the addition of fibre ingredients. The effect of functional fibre fortification of pureed foods on sensory acceptability is not known. The objective of this study was to determine the acceptability of pureed foods fortified to offer 2 g of pea hull fibre per serving of pureed food. Potato, carrot, beef and beef stew purees, fortified with pea hull fibre and having the target viscosity of pudding, were prepared. Discriminative sensory analyses were carried out by non-dysphagic panelists to determine if purees containing pea hull fibre differed from control purees containing soy cotyledon fibre (commonly used in commercial products). Trained panelists completed further descriptive evaluation of aroma, flavour, adhesion, cohesion, particles, particle size, smoothness, viscosity, dryness, residual particles and mouthcoating using five-point, Likert-like scales. It was determined that products fortified with pea hull fibre differed from those of soy cotyledon, and that the grittiness, adhesiveness and viscosity of the pureed foods were substantial. Pea hull fibre was found to significantly contribute to viscosity.

3.7 Viscosity Characteristics of Pureed Foods Fortified with Fibre

Chapter 9 describes the viscosity characteristics of pureed foods fortified with fibre. The requirement for dysphagic pureed foods to be monophasic, smooth, cohesive and thick may be achieved by the addition of high-fibre ingredients. The objectives of this investigation were to describe the viscosity characteristics of fibre-fortified pureed foods and to determine the effects of incremental increases in the levels of finely processed, insoluble fibre on the viscosities of pureed foods (vegetable, meat, starch and casserole), while maintaining the monophasic state throughout the freeze-thaw-reheat cycle. Beef, carrot, potato and beef stew pureed foods were assessed for viscosity at varying temperatures, shear rates and levels of microcrystalline cellulose.

3.8 Discussion

Significant product development and quality control procedures, required for successful and widespread implementation of fibre fortification of institutional diets, are discussed in this final chapter of this thesis.

4. THE EFFECT OF PEA HULL FIBRE ON LAXATIVE USE, BOWEL HABITS AND FOOD ACCEPTANCE IN LONG TERM CARE RESIDENTS

4.1 Introduction

Constipation is a major health problem in the institutionalized elderly (Talley et al, 1992). Although strong evidence exists which supports the relationship between fibre intake and the prevention and alleviation of constipation (ADA, 2002), pharmaceutical therapies are often the treatment of choice for constipation in the institutionalized elderly (Dahl & Wasko-Lacey, 1999; Quail, 1998). Limited research has been carried out on the effect of a high fibre diet on the prevalence of laxative use in long term care residents. Although the elderly may avoid typical high fibre foods due to preferences or chewing difficulties, the effects of adding finely processed fibre to the diets of long term care residents have not been investigated. The following study of the effects of pea hull fibre on bowel habits, laxative use and food acceptance of long term care residents was designed to be an intervention to be carried out in a fully operational long term care facility with the inherent systemic and staff issues that may arise.

4.2 Methods

4.2.1 Study Population

Luther Special Care Home is a 229 bed, long term care facility operated by LutherCare Communities, an organization reporting to the Evangelical Lutheran Church of Canada. Luther Special Care Home, as with most Saskatchewan long term care homes, houses, for the most part, elderly individuals with ever-increasing debility and care needs. It is one of only two facilities in Saskatoon, Saskatchewan with a secured dementia unit.

4.2.2 Ethics and Consultations

An application for ethical approval was submitted to the University of Saskatchewan Advisory Committee on Human Experimentation (Biomedical Sciences). In addition, an oral presentation of study design and methods was made to the LutherCare Communities Ethics Committee. Written approval to carry out this study was received from both of these committees. Following ethics approval, meetings were held to inform management, dietary and nursing staff of the study. A detailed memo was also sent to inform the Nursing Department. Residents and family were informed through resident and family meetings and the facility newsletter. Prior to the intervention, chart reviews were carried out by a Clinical Dietitian to determine if the consumption of a high fibre diet was contraindicated for any residents. Written consent (**Appendix A**) was gathered from cognitively functional residents and family, and the Director of Nutrition and Food Services provided consent to initiate the addition of pea hull fibre to the diet. The certificate of approval for the study protocol can be found in **Appendix B**.

4.2.3 Menu Analysis

Menu analysis was carried out to determine the usual fibre and other nutrient contents of the standard five-week rotation menu. Head cooks were instructed to record all ingredients, amounts and numbers of servings prepared for the five-week rotation menu. The resulting data was then analyzed using Food Processor® (Nutrient Assessment Program, ESHA Research, Salem, OR). The average daily nutrient composition of foods offered in the usual menu and, specifically, the average level of dietary fibre were determined.

4.2.4 Fibre Intervention

The six-week intervention study was conducted from May 22 to July 1, 2001. Baseline data on chart information, laxative use and bowel habits was collected April 1-30; corresponding treatment data were collected June 1-30. Food waste data collection was completed May 15-18 (baseline) and June 19-22 (treatment). Bioelectric Impedance Analysis measurements were taken May 8-18 (baseline) and June 25-29 (treatment) to determine hydration status.

In pilot studies, acceptance of finely processed pea hull fibre (Exlite®, Parrheim Foods, Saskatoon, SK) in institutional foods was tested using eighteen young adults and nineteen elderly volunteers. Preliminary testing indicated acceptability of pea hull fibre, at less than 3 g/serving, to foods that underwent subsequent cooking with sufficient moist heat. Based on the preliminary testing, head cooks were instructed to add finely processed pea hull fibre to three identified menu items per day at 1-3 g/serving. For those food items containing wheat flour, cooks were instructed to replace the flour with fibre at a 1:1 ratio. A record sheet was placed in the kitchen, and head cooks signed for each food supplemented with fibre and indicated the amount of pea hull fibre added and the number of servings prepared.

4.2.5 Food Acceptance

Our objective measure of food acceptance was a lack of an increase in food wastage. Food wastage was measured on seventeen food items. Data was collected for one week prior to fibre addition and compared to one week during the treatment period, allowing a comparison of food acceptance with and without added fibre.

Of the total resident population, thirteen were sufficiently cognitively functional and were interviewed regarding food acceptance. Residents were asked to rate the food offered in recent weeks using a five-point, Likert-like scale, and if they noticed any change in the food. **Appendix C** contains the questions posed regarding food acceptance. If a change in the food was noted, residents were asked to provide specifics related to the perceived change.

4.2.6 Subject Monitoring of Bowel Movement Frequency, Fecal Output, and Laxative and Enema Use

Chart data using the Extendicare™ format was collected for a four-week baseline period and for the last four weeks of the treatment period. To ensure anonymity, the names and health service numbers were removed from chart copies and replaced with a subject number. Chart data collected included the number of administered laxatives, enemas and other medication, bowel movement frequency and recorded output, recorded food intake, disease states, length of stay, and subject's demographic characteristics.

The standard practice of charting bowel movements in the facility was by fecal output size, specifically, small, medium, large, extra-large and normal. Charting of a bowel movement as "normal", were recorded as "medium". No attempt was made to modify or quantify the standard practice of bowel movement reporting. Care staff were responsible for reporting the number and size of bowel movements to their respective nursing supervisor at the end of each shift. The nursing supervisor was responsible for charting. The total number of bowel movements per month was determined by summing all charted bowel movements. Recorded output was determined by a weighting system. Bowel movement size was noted and a weighting factor assigned (small=1, medium=2, large=3, extra large=4). The factors were multiplied by the recorded number of bowel movements in each size category. Frequency was expressed as the number of recorded bowel movements per month, and fecal output was expressed as weighted stool frequency/month. Laxatives were categorized under the following headings: standardized sennosides (e.g. Senokot®), docusate sodium (e.g. Colace®), other enema preparations (e.g. Microlax ®), prune/fruit puree (e.g. Delnor® brand), sodium phosphates (e.g. Fleet Enema®) and lactulose. The total number of administrations of laxatives and enemas per resident was determined; however, the dosage of each laxative was not determined.

Residents with bowel movement frequencies of less than ten per month were analyzed as a subset, in that these residents were considered at greatest risk for enema administration and it was facility policy to administer an enema to individuals who had not had a bowel movement for three days. In addition, bowel movement frequencies of less than ten per month, i.e. less than once every three days, meets the common clinical practice definition of constipation.

Bioelectric impedance analysis was carried out on a convenient sub-sample of residents at baseline and in week five (n=31) of the intervention period for the purpose of monitoring fluid status in study subjects. Measurements of reactance and resistance (at 50 Mhz) using bioelectric impedance spectrophotometry (RJL Systems, Model 101A, Clinton Twp, MI) were obtained from residents who were fasting (3-12 hrs), dry and in a prone position to determine total, intracellular and extracellular body water. Total body water was determined using the Vache equation (Vache, Rousset, Gachon, Gachon, Morio, Boulier, Coudert, Beaufrere & Ritz, 1998).

4.2.7 Facility Acceptance

Self-administered exit surveys were developed for dietary and nursing staff to determine perceptions of workload, success/failure of the study, perceived acceptance of fibre-fortified foods and perceived clinical effects. Dietary staff rated the success of the study with regards to food acceptance as "somewhat successful" to "very successful". Staff were encouraged to complete and submit the surveys. An example of the staff survey is provided in **Appendix D**.

4.2.8 Data Analysis

Data were compiled and recorded into spreadsheets. Statistical analysis was carried out using SPSS Version 10.0 (SPSS Inc., Chicago, IL). The primary statistical tests applied were paired t-tests and Pearson correlations. Values are expressed as mean $\pm$ standard deviation (SD). Significance was set at $\alpha = 0.05$.

4.3 Results

4.3.1 Subject Information

Of the 129 residents in the facility, a number were excluded as study participants for the following reasons: three residents were respite, three residents were tube fed, two were recent admissions to the facility and were not residents at baseline, three were admitted to hospital during the baseline or intervention period, two were away for more than one day during the study, one died and one resident was palliative and NPO (nothing by mouth). **Table 4.1** provides characteristics of the study participants (n=114) at baseline and the characteristics of the subset of participants (n=17) that had baseline bowel frequencies of less than ten per month. Over the course of the six-week treatment period, body weight did not change.

Total body water showed a statistically significant increase, from 29.7 kg at baseline to 30.9 kg during the fibre intervention period ($p = 0.002$).

Table 4.1. Characteristics of subject participants (n=114) and the subgroup with low bowel frequency (n=17) at baseline.

	Subject Population	Subgroup[a]
Number	114 (34 M[b]; 80 F[c])	17 (5 M[b]; 12 F[c])
Age (y)[d]	83.9 (49-103)	83.3 (59-99)
Weight (kg)[d]	60.9 ± 15.4	65.2 ± 18.2
	(29.3 -104.1)	(32.3 - 104.1)
Diet: Regular/Ground	79%	67%
Pureed	21%	33%
Medical Conditions:		
Dementia	61 (54%)	10 (66%)
Hypertension	22 (19%)	4 (24%)
Renal/Pulmonary	5 (4%)	2 (13%)
Cancer	4 (4%)	0
Stroke	15 (13%)	3 (18%)
Artritis	25 (22%)	2 (13%)
Osteoporosis	10 (9%)	0

[a] Residents with low bowel frequency (< 10 bowel movements per month)
[b] Men
[c] Women
[d] Mean ± SD (range)

4.3.2 Fibre Fortification of the Menu

The usual fibre level offered, per standard meal day, in the five-week rotation diet was 18.5 g/day, including snacks. A standard meal day was defined as the standard portions of all foods offered in a given day, and provided on average of 8.3 MJ of energy and 77 g of protein. Pea hull fibre was added to two to four food items per day, for a total of 4.0 g per meal day (3.6 g/meal day of dietary fibre; range 2.2-7.3 g per meal day). Food items fortified with pea hull fibre and their pea hull fibre content are listed in **Table 4.2.**

4.3.3 Acceptance of Fibre fortification

No difference was found between food waste in the control (10 g/serving) and treatment (11 g/serving) periods (p=0.73). Of the thirteen cognitively functional residents interviewed regarding food acceptance, ten rated the food as good, one as very good, and two as fair. Eleven indicated they noticed no change in the food over the past few weeks, one resident indicated that she did notice a change, but her comment was unrelated to the addition of pea hull fibre, and the other resident declined to answer this question. Dietary staff (n=8) who completed an exit survey indicated that staff workload and residents' acceptance of the food had not changed during the study, and that food wastage had not changed.

Table 4.2. Pea hull fibre contents (g) in each serving of foods fortified with fibre.

Meal Items:	Pea fibre (g)	Snack Items:	Pea fibre (g)
Cream of Wheat	1.3	Chocolate muffins	2.5
Oatmeal	1.9	Muffins unspecified	1.0
Gravy	0.8	Cookies unspecified	0.6
Pancakes	1.0	Matrimonial Cake	1.7
Swiss Steak	1.0	Cake unspecified	1.7
Pork Cutlets	2.0	Cinnamon bread	2.1
Meatballs	0.8	Carrot Cake	1.8
Baked Beans	1.3	Gingerbread	2.1
Stew Dumplings	1.5	Muffins	1.9
Chicken Pot Pie	0.9	Raisin Pudding	2.0
Lazy Cabbage Rolls	1.1		
Bean Soup	0.9		
Quiche Lorraine	0.9		
Meatloaf	2.0		
Salisbury Steak	2.0		
Apple Crisp	1.5		
Norwegian Meatballs	1.5		
Beef Stew	1.3		

4.3.4 Bowel Function and Laxative Use

Seventy-eight percent of residents were prescribed and administered at least one type of laxative or enema in the baseline month, with 44% administered two, 18% administered three, and 4% administered four laxatives or enemas. Enemas were used as the most common treatment for perceived constipation. A significant increase was found in bowel frequency in the intervention period compared to baseline for all residents (n=114); the results are shown in **Table 4.3.** For the sub-sample of residents with bowel frequencies of <10/month (n=17), significant increases in both reported output and bowel frequency were found; these results also are shown in **Table 4.3**. Laxative use and enema administration remained unchanged over the course of the fibre intervention, except for the significant decrease that was noted in fruit/prune puree administration.

Table 4.3. Bowel movement frequency, reported fecal output and laxative use at baseline and during fortification with 4 g/meal day of pea hull fibre.

	Baseline[a]	Dietary Fibre[a]	Baseline[b]	Dietary Fibre[b]
BM Frequency[c]	18.7 ± 9.4	20.1 ± 9.6*	8.8 ± 1.0	12.6 ± 3.8*
Laxatives/Enemas[d]				
Lactulose	4.9 ± 14.5	5.5 ± 15.1	1.7 ± 7.0	3.4 ±14.1
Sennonsides	4.8 ± 12.7	6.0 ± 14.6	10.4 ±17.4	9.7 ± 17.3
Docusate Sodium	8.0 ± 19.3	8.9 ± 20.2	5.0 ± 11.2	10.8 ± 20.1
Fruit/prune puree	16.3 ± 26.1	10.8 ± 22.4*	27.6 ± 33.2	23.2 ± 31.7
Fleet Enema®	0.6 ± 1.6	0.6 ± 1.6	2.2 ± 0.6	2.5 ± 2.8
Microlax®	1.0 ± 1.4	1.1 ± 1.6	1.8 ± 1.8	2.2 ± 2.4

[a] n = 114; mean ± SD

[b] n = 17; mean ± SD

[c]Bowel Movement Frequency (Bowel movements/month)

[d]Average administrations per month

* Statistical significance at $p < 0.01$

4.4 Discussion

Constipation is best prevented by the consumption of a diet high in dietary fibre. Diets high in dietary fibre result in increased stool weight and reduced transit time (Cummings, 1993). The Dietary Reference Intakes give an AI of fibre for the elderly over the age of 70 years at 21 and 30 g/day for elderly women and men, respectively (IOM, 2002).

The effect of adding fibre to the diets of institutionalized elderly has been investigated but most studies have used wheat bran. Although wheat bran is an effective fibre source, it changes the texture and flavour of foods and has been shown to be unpalatable (Kochen et al, 1985). Many studies have used a single fibre-fortified food or supplement (Hull et al, 1980; Rajala et al, 1988; Hankey et al, 1993). The drawback of providing fibre in a single food is that residents must consume that specific food item to benefit. Administration of a fibre supplement in addition to the usual menu items requires staff time and may result in rejection (Hankey et al, 1993). Studies using prune puree or prune juice in high fibre formulations (Gibson, Opalka et al., 1995) may be adding more than dietary fibre, as prunes contain potent phenolic compounds with stimulant laxative effects, as well as sorbitol, an osmotic laxative (Stacewicz-Sapuntzakis et al, 2001). Thus, fibre intervention studies including prunes are difficult to interpret. None of the research thus far has investigated the effects of adding finely processed dietary fibre to the diets of the institutionalized elderly.

The level of dietary fibre offered in the facility prior to the study was 18.5 g/day, was less than the current recommendation for dietary fibre of (IOM, 2002). As residents of long term care facilities do not consume a standard portion of foods offered, but on average consume two-thirds of what is offered (Lengyel, 2002), it is likely that residents of the facility may have consumed no more than 10 g/day of dietary fibre. Insufficient dietary fibre intake may be one reason for the high rate of laxative use in the facility.

A moderate increase in fibre resulted in a significant increase in bowel movement frequency for the resident population as a whole, and for both frequency and reported stool output for those residents with bowel movement frequencies of less than ten per month. Although it is often suggested that increased dietary fibre intake be accompanied by increased fluid intake. The study protocol did not include any intentional increase in fluid offered. Therefore, the significant bowel effects resulting from increased fibre occurred without a known concurrent increase in fluid intake. As an increase in total body water was observed, the addition of fibre without a recommendation for additional fluid intake appeared to have no negative effect on fluid status.

There was a significant decline in the rate of administration of fruit/prune puree. Fruit/prune puree was the only laxative on the medication sheet that could be changed without the approval of the attending physician. The administration of pharmaceutical laxatives, however, did not decrease. Likewise, enema administration did not change, although facility policy states that the administration of enemas is based on stool frequency. This observation suggests that there was a lack of assessment of need prior to the administration of enemas and laxatives. However, the study length may not have been sufficient for assessment, physician consultation and administration changes to be realized.

The use of laxative and enema administration in the facility was assessed at baseline. Docusate sodium was administered to 16% of residents, although it may not be efficacious in the long term treatment of constipation in the elderly (Castle et al, 1991). Likewise, 32% of residents were administered fruitlax providing approximately 10 g/day prune puree, one to three times per day, a dose substantially less than the 100 g/day required to give a therapeutic effect (Tinker et al, 1991). Sennoside products were administered to 15% of residents at thirty to sixty doses per month, which may have contributed to the severity of constipation observed due to their resulting bowel dependency. Enemas were administered to 58% of residents. Some enemas were administered less than three days after a bowel movement, which was not in accordance with facility policy. Thirty-one residents who received an enema in the control period were not administered any other laxatives. Lactulose, which has the least risk and proven effective in the prevention and treatment of constipation in the elderly, was administered to only 12% of residents. The data collected suggest that enema administration, with its inherent risks and discomfort, may have been used inappropriately and as the first-line treatment for constipation. The results suggest that adding dietary fibre would improve quality of life by reducing enema use if appropriate assessments of need were undertaken.

Even though the residents of the special care home were informed of the study and the addition of fibre to the usual menu items, the added fibre did not change food acceptance by the residents. The cooks added small amounts of fibre in the beginning of the study, as they were unsure how the fibre would affect the sensory characteristics of the food. The cooks also required some time to become familiar with the process of adding pea hull fibre to the menu cycle.

4.5 Conclusion

Experienced cooks incorporating pea hull fibre into usual menu items is a viable method of increasing the amount of total fibre offered to long term care residents. The results of this study indicate that finely processed pea hull fibre can be successfully incorporated into the usual menu items offered to long term care residents. The level of fibre offered to long term care residents is insufficient to meet recommendations and is contributing to the prevalence of constipation and laxative use in long term care facilities. Finely processed fibre, such as pea hull fibre, can be successfully incorporated into the usual foods offered in a long term care facility, with a corresponding significant improvement in bowel function. Thus, corrective interventions related to constipation and laxative use in long term care facilities do not need to rely solely on pharmaceuticals. Instead, positive change can be achieved by a low cost, acceptable fibre fortification. Fortification with a finely processed fibre such as pea hull fibre may make it possible for long term care residents to achieve the AI for fibre.

5. SENSORY AND TEXTURAL EVALUATION OF BAKED GOODS FORTIFIED WITH PEA HULL FIBRE

5.1 Introduction

Functional fibre is defined as "isolated, non-digestible carbohydrates that have beneficial physiological effects in humans" (IOM, 2002), and when incorporated into usual foods may serve to increase fibre intakes. Bakery items, such as bread and muffins, may be the ideal vehicle for insoluble, functional fibre fortification in the long term care diet, as these food vehicles have been used successfully to increase intakes of micronutrients such as folate. However, the addition of insoluble fibre to baked products may affect their appearance, flavour and texture.

Although flavour is most easily assessed by sensory evaluation, food texture and appearance can be assessed subjectively by sensory evaluation or objectively using mechanical measurements. The Texture Profile Analyzer (TPA) is capable of providing data on textural characteristics such as hardness, adhesiveness, cohesiveness and fracturability. Hardness, "the peak force of the first compression of the product"

(Szczesniak, Brandt & Friedman, 1963), is an important textural characteristic with respect to the acceptability of baked products. Most bread, muffins and other baked goods are preferred when less hard. Staling or starch retrogradation can increase hardness and diminish acceptability of baked goods.

Appearance of foods can be assessed with a colorimeter. A tristimulus colorimeter employs the L, a, b scale, with "L" representing lightness (ranging from 100 for perfect by white to zero for black). The "a" value is a measure of redness when plus and greenness when minus, and "b" measures yellowness when plus and blueness when minus.

Fortification of baked goods with insoluble fibre may be achieved with pea hull fibre. Pea hull fibre is a finely ground fibre ingredient derived from the hull of the yellow field pea. Exlite® pea hull fibre (see **Appendix E** for specifications), produced by Parrheim Foods, Saskatoon, SK, and as described in Chapter 4, increases stool output and bowel movement frequency when added to the foods offered to long term care residents. Centara III® pea hull fibre (**Appendix F** for specifications), produced by Parrheim Foods, Portage la Prairie, MB, is an approved novel fibre source in Canada (Health Canada, 1996) with proven efficacy in fecal bulking (Stephen, Morgan, Dahl & Nickel, 1992). Exlite® and Centara III® are finely ground, off-white fibre sources with total dietary fibre contents of greater than 78% and 90%, respectively, but differ in their processing. Exlite® is produced by abrasion dehulling and grinding Centara III® undergoes an additional washing and drying step prior to grinding (Personal Communication; K.A. Fulcher, August 2001). Centara III® is a food-grade, vegetable fibre and is particularly suitable for use in bakery and cereal products such as tortillas, crackers, bagels, cereals, pasta and bread (**Appendix F**). Exlite® is similarly also recommended for use in pasta and baked goods.

Published research on the baking quality, texture and sensory acceptability of bakery products fortified with pea hull fibre is scarce. Although the fortification of institutional foods with Exlite® appeared to be acceptable as food wastage did not change (as presented in Chapter 4), it is not known if the sensory acceptabilities of baked products containing Exlite® fibre would be significantly different than those of non-fibre-fortified products. It is also not known if Centara® fibre affects the sensory acceptability of baked products. Furthermore, the effects of Exlite® and Centara® fibre on baking quality are not known. As fortified foods intended for the institutionalized elderly must be highly acceptable, the sensory and textural characteristics of baked goods fortified with pea hull fibre required evaluation. It was hypothesized that pea hull fibre could be incorporated into products such as bread, muffins, cookies and pancakes without detrimental effects on their sensory and textural attributes. Hence, the primary objective of this investigation was to determine the effects of pea hull fibre (Exlite® and Centara III®) fortification on the textural and sensory characteristics of baked products. Secondary objectives were to evaluate the effect of pea hull fibre on the shelf life and quality of baked products.

5.2 Methods

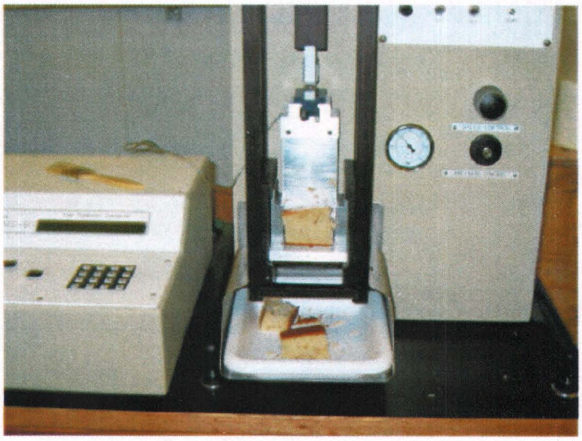
5.2.1 Product Preparation

Baked goods fortified with pea hull fibre were developed at the Product Development Laboratory, College of Agriculture, University of Saskatchewan. All preparation and baking procedures were held constant for corresponding controls and products containing pea hull fibre. Shortbread cookies, muffins, cakes and bread-machine breads were prepared in duplicate with and without Exlite® or Centara III® pea hull fibre. White bread was fortified at a level of 1.5 g of pea hull fibre per 25 g slice (65.6 g of fibre per loaf). White cake was fortified at 2 g of pea hull fibre per serving (32 g of fibre per cake). Cookies (25 g precooked weight) were fortified at 2 g of pea hull fibre per cookie (38 g of fibre per batch). Muffins (80 gram precooked weight) were fortified at 3 g of pea hull fibre per muffin (23 g of fibre per batch). Products were first prepared with a simple gram for gram substitution of wheat flour with pea fibre. Formulations were then optimized with additional water. **Appendix G** provides formulations for both control and optimized baked products fortified with fibre.

5.2.2 Evaluation of Texture and Baking Quality

Hardness was analyzed using the Texture Profile Analyzer (TPA) (Model TMS 2000, Food Technology Corporation) using the single blade shear cell **(Figure 5.1)**. The loaf height of muffins and bread was determined by slicing muffins or loaves in half and measuring the height (in cm) with a ruler. The color of bread, cake and cookies was determined using a tristimulus photoelectric colorimeter (Hunterlab Colorflex Spectrophotometer Model 45°/0°, Hunter Associates Laboratory, Inc., Reston, VA).

Figure 5.1. Texture Profile Analyzer



5.2.3 Sensory Evaluation

A certificate of ethics approval for sensory evaluation was received from the University of Saskatchewan Advisory Committee on Ethics in Human Experimentation (Biomedical Sciences) in June, 2003 (**Appendix H**). Informed consent for participation in the sensory evaluation was obtained from fifty-two university staff and students. An example of the consent form is provided in **Appendix I**. Two sensory evaluation sessions were carried out in July, 2003. (See section 8.2.2.2 for sensory evaluation conditions). Likert ratings of sensory attributes of Exlite® and Centara III® fibre-fortified and control cookies and cake were completed by untrained sensory volunteers. Appearance, flavour, mouthfeel, texture, moisture and overall acceptability were evaluated with rankings from "1" for "unacceptable" to "5" for "highly acceptable". An example of the sensory evaluation tool can be found in **Appendix J**.

5.2.4 Statistical Analysis

Unpaired t-tests were used to compare loaf heights of muffins and bread fortified with Exlite® or Centara III® to controls and to compare the hardness of muffins, cookies, cake and bread fortified with Exlite® or Centara III® to controls. Unpaired t-tests were also used to compare L, a, b color differences between control s and cookies, bread and cake fortified with Exlite® or Centara III® to controls.

5.3 Results

5.3.1 Textural and Baking Quality of Baked Products

Results for loaf height and hardness are presented in **Table 5.1.** The hardness of cookies and bread was reduced by the addition of pea hull fibre. Bread containing pea hull fibre was still softer than the control bread after seven days ($p < 0.001$). Hardness of muffins and cake was not altered significantly by the addition of pea hull fibre. Likewise, the loaf height of bread was not reduced significantly by the addition of pea hull fibre. However, the loaf height of muffins was reduced by the addition of pea hull fibre. **Figures 5.2, 5.3 and 5.4** provide visual details of the baked products.

Table 5.1. Height (cm) and hardness (N) of muffins, cake, cookies and bread.

Food Product	Loaf Height (cm)	Hardness (N)
Control Muffin[1]	$5.7 \pm 0.1^{a\,5}$	14.8 ± 1.7^{a}
Centara Muffin[1]	5.5 ± 0.1^{ab5}	13.4 ± 1.8^{a}
Exlite Muffin[1]	5.4 ± 0.2^{bc5}	14.8 ± 1.1^{a}
Control Cake[2]	—	11.9 ± 1.5^{a}
Centara Cake[2]	—	10.9 ± 2.3^{a}
Exlite Cake[2]	—	11.4 ± 1.7^{a}
Control Cookies[3]	—	107.0 ± 16.0^{a}
Centara Cookies[3]	—	67.4 ± 8.1^{b}
Exlite Cookies[3]	—	71.6 ± 6.5^{b}
Control Bread[4] Day 1	22.5[6]	48.5 ± 4.7^{a}
Day 3		37.9 ± 0.9^{a}
Day 7		42.2 ± 7.1^{a}
Centara Bread[4] Day 1	22.0[6]	35.2 ± 3.1^{b}
Day 3		29.7 ± 2.7^{b}
Day 7		27.4 ± 3.7^{b}
Exlite Bread[4] Day 1	21.5[6]	33.0 ± 3.7^{b}
Day 3		23.4 ± 2.2^{c}
Day 7		17.0 ± 3.5^{c}

Replications: [1] n=10, [2] n=3, [3] n=10 [4] n=4 [5] n=3 and [6] n=1
Loaf height was not determined on cake and cookies. Values within a column for a particular product and followed by the same superscript are not significantly different at $p < 0.05$.

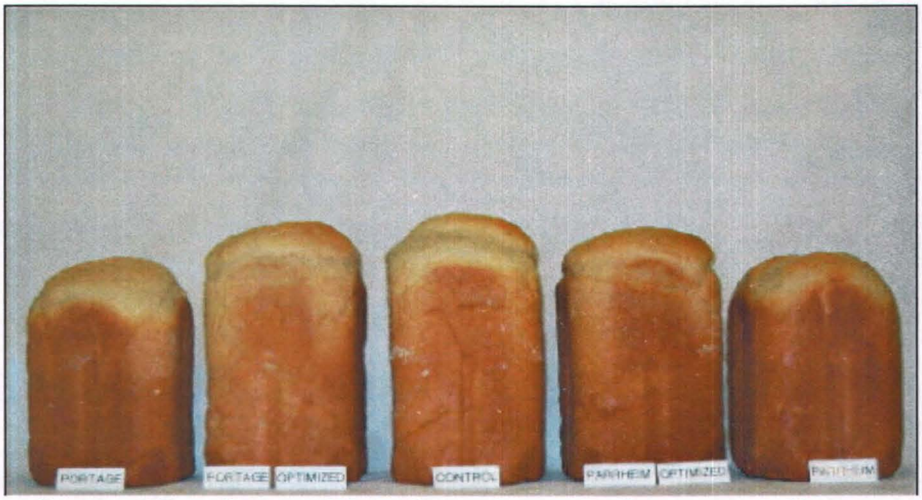
Results of the colour analyses are presented in **Table 5.2**. Cookies and cake fortified with Centara III® pea hull fibre were significantly darker than the corresponding controls, whereas bread fortified with Centara III® was not darker than the control. In addition, Centara III®-fortified cake was less red than the control cake. Cookies and bread fortified with Exlite® were darker than the corresponding controls. Exlite®-fortified cake was less red than the control cake. No significant differences were found between baked products containing Centara III® or Exlite® pea fibre and corresponding controls with respect to yellowness/blueness.

Table 5.2. Colour analyses of control cake, cookies and bread and corresponding products fortified with Centara III®- and Exlite® pea hull fibre (Lab D65/10).

Product[1]	L	a	B
Control Cake	56.8 ± 6.4 ^{a}	14.5 ± 4.5 ^{a}	37.4 ± 2.6 ^{a}
Centara Cake	58.6 ± 6.2 ^{a}	12.2 ± 4.8 ^{b}	36.1 ± 3.1 ^{a}
Exlite Cake	56.8 ± 5.4 ^{a}	12.1 ± 3.8 ^{b}	33.4 ± 3.0 ^{b}
Control Cookie	82.2 ± 0.5 ^{a}	1.7 ± 0.1 ^{a}	16.1 ± 0.4 ^{a}
Centara Cookie	77.2 ± 0.5 ^{a}	1.9 ± 0.1 ^{a}	15.9 ± 0.3 ^{a}
Exlite Cookie	75.1 ± 0.9 ^{a}	1.3 ± 0.0 ^{a}	14.9 ± 0.3 ^{a}
Control Bread Top	64.8 ± 5.9 ^{a}	8.5 ± 3.4 ^{a}	22.2 ± 1.3 ^{a}
Control Bread Side	46.6 ± 3.0 ^{a}	13.9 ± 0.9 ^{a}	19.2 ± 0.5 ^{a}
Control Bread Crumb	68.5 ± 1.4 ^{a}	1.2 ± 0.1 ^{a}	15.2 ± 0.6 ^{a}
Centara Bread Top	65.1 ± 4.8 ^{a}	7.8 ± 2.6 ^{ab}	20.9 ± 1.0 ^{b}
Centara Bread Side	46.5 ± 1.9 ^{a}	14.1 ± 0.5 ^{a}	19.5 ± 0.5 ^{b}
Centara Bread Crumb	65.0 ± 0.8 ^{b}	2.0 ± 0.1 ^{b}	15.9 ± 0.1 ^{b}
Exlite Bread Top	56.8 ± 4.1 ^{b}	10.5 ± 1.9 ^{ac}	21.2 ± 0.5 ^{b}
Exlite Bread Side	43.5 ± 2.1 ^{c}	13.8 ± 0.5 ^{a}	18.3 ± 0.6 ^{c}
Exlite Bread Crumb	62.9 ± 0.9 ^{c}	2.2 ± 0.1 ^{c}	15.5 ± 0.2 ^{ac}

[1] Ten replications were carried out on cookies and cake, and eight for bread. Values within a column for a particular product and followed by the same superscript are not significantly different at $p < 0.05$.
L value: measures lightness varying from 100 for perfect white to zero for black
a value: measures redness when plus and greenness when minus
b value: measures yellowness when plus and blueness when minus.

Figure 5.2. Control bread and breads fortified with Centara III® and Exlite® pea hull fibre, with and with out optimization with added water.

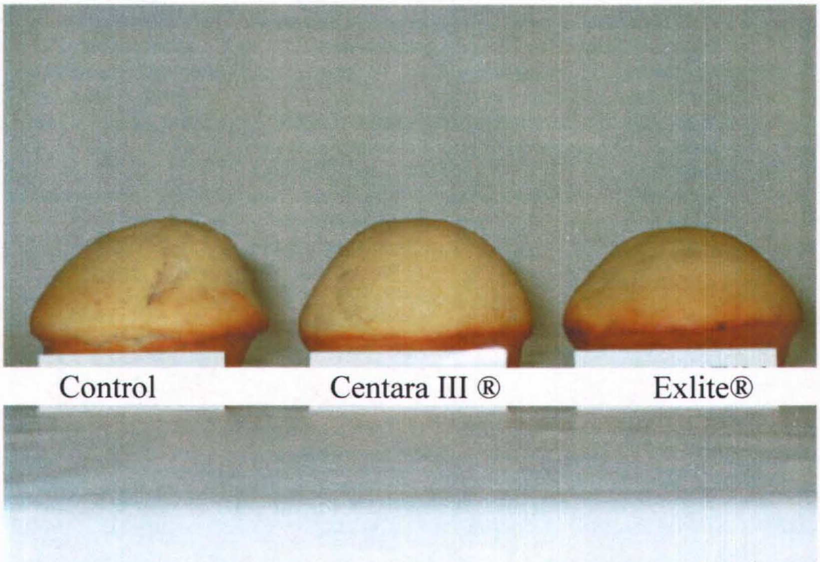


Centara III | Centara III Optimized | Control | Exlite Optimized | Exlite

Figure 5.3. Control bread and breads fortified with Centara III® and Exlite® pea hull fibre optimized with the additional water.

Centara III Optimized | Control | Exlite Optimized

Figure 5.4. Control muffin and muffins fortified with Centara III® and Exlite® pea hull fibre.



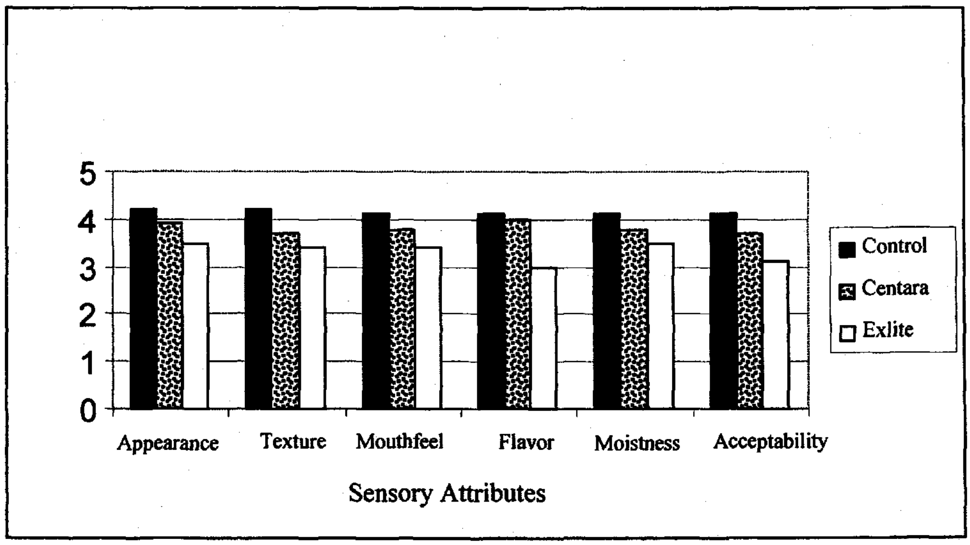
5.3.2 Sensory Evaluation

The results of the sensory evaluation of cake are displayed in **Figure 5.5**. The acceptability ranking of appearance decreased from the control raking of 4.19 ± 0.81 to 3.98 ± 0.72 ($p<0.01$) and 3.49 ± 0.97 ($p<0.001$) for cakes fortified with Centara III® and Exlite® pea hull fibre, respectively. The texture ranking for the control cake was 4.15 ± 0.69 compared to 3.74 ± 0.81 ($p<0.001$) and 3.36 ± 0.94 ($p<0.001$) for Centara III® and Exlite® pea hull fibre, respectively. Mouthfeel for the control cake of 4.06 ± 0.87 decreased to 3.75 ± 0.83 ($p<0.01$) and 3.41 ± 0.91 ($p<0.001$) for cakes fortified with Centara III® and Exlite®, respectively. The average flavour ranking for the control cake was 4.09 ± 0.95, compared to 3.98 ± 0.75 (NS) and 2.96 ± 0.96 ($p<0.001$) for cake fortified with Centara III® and Exlite® pea hull fibre, respectively. The average moistness ranking for the control cakes was 4.08 ± 0.87, whereas the Centara III®-

fortified cake was ranked at 3.77 ± .97 ($p<0.001$) and the Exlite®-fortified cake at 3.49 ± 0.99 ($p<0.001$). The overall acceptability of the control cake was ranked higher at 4.08 ± 0.83, compared to the Centara III®-fortified cake at 3.74 ± 0.74 ($p < 0.01$) and the Exlite®-fortified cake at 3.09 ± 0.77 ($p < 0.001$).

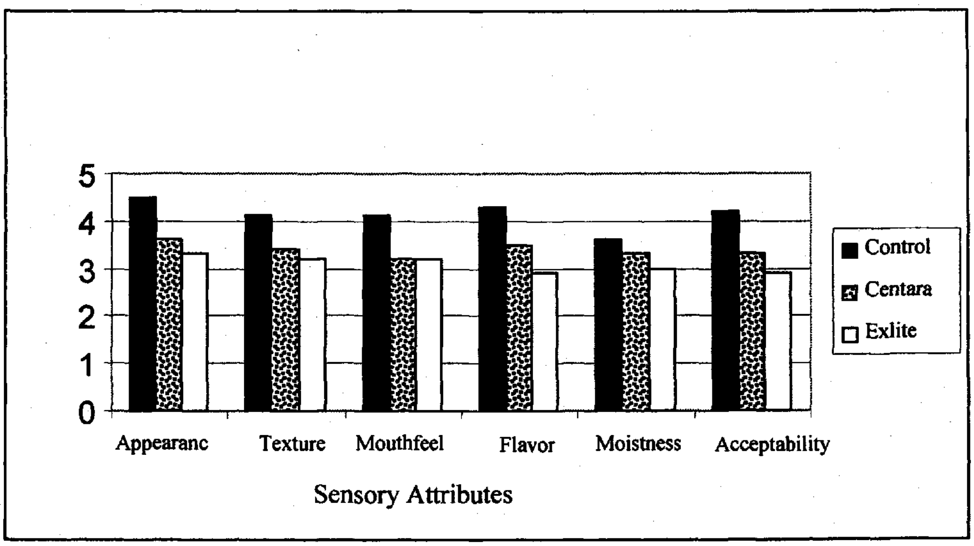
The acceptability of the textural qualities of shortbread cookies was reduced significantly by the addition of pea hull fibre. However, most characteristics remained acceptable. The results are displayed in **Figure 5.6**. In particular, the appearance ranking decreased from 4.51 ± 0.67 for the control cookie to 3.64 ± 0.86 ($p<0.001$) for the Centara III®-fortified cookie and 3.28 ± 0.99 ($p<0.001$) for the Exlite®-fortified cookie. The texture ranking for the control cookie was 4.09 ± 0.81 compared to 3.40 ± 1.10 ($p< 0.001$) for the Centara III®-fortified cookie and 3.21 ± 0.97 for the Exlite®-fortified cookie ($p<0.001$). Mouthfeel was similarly reduced from 4.08 ± 0.92 to 3.32 ± 1.17 ($p<0.001$) and 3.15 ± 1.06 ($p<0.001$) with the addition of Centara III® and Exlite® respectively. Flavour of control cookies (4.28 ± 0.72) was ranked significantly higher than Centara III® (3.45 ± 1.05) ($p < 0.001$) and Exlite ®cookies (2.87 ± .86) ($p < 0.001$). Moistness of cookies for the control was ranked similarly for control (3.58 ± 1.06) and Centara III® (3.30 ± 1.08) (NS) cookies, but Exlite® cookies were ranked significantly lower at 3.02 ± 1.04 ($p < 0.001$). Overall acceptability of control cookies was 4.17 ± 0.83, while Centara III® and Exlite® were ranked lower at 3.87 ± 0.93 ($p<0.001$) and 3.32 ± 1.05 ($p<0.001$), respectively.

Figure 5.5. Sensory characteristics of control, Centara III® and Exlite® cake (n = 26).



Rankings ranged from "1" for unacceptable to "5" for highly acceptable.

Figure 5.6. Sensory characteristics of control, Centara III® and Exlite® cookie (n = 26).



Rankings ranged from "1" for unacceptable to "5" for highly acceptable.

5.4 Discussion

In this investigation, shortbread cookies, white cake, plain muffins and white bread were chosen as vehicles for fibre enhancement as these simple foods are unlikely to mask any potential adverse taste or textural characteristics that may result from the addition of a high fibre ingredient. As tenderness, a preferred attribute for baked products, was improved (i.e. hardness was decreased) in cookies and bread by the addition of pea hull fibre, this product-enhancing effect should be investigated further. The colour of the products was enhanced through the more intense browning which resulted from the addition of pea hull fibre.

Although most sensory attributes were diminished by the addition of Exlite® or Centara III® pea hull fibre to cookies and muffins, most sensory characteristics remained in the acceptable range, particularly for those products fortified with Centara III® fibre. Cake, cookies and muffins with variations in flavours and textures could serve to mask reductions in flavour and texture due to fibre fortification, and likely would result in a product with no loss in acceptability.

Although the fibre fortification of baked products is intended for elderly residing in long term care facilities, younger sensory panelists were used in the evaluation of the products. As Drewnowski et al (1996) state, elderly show decreased acuity in odour and taste acuity. Therefore, younger sensory panelists may be more discrimitative.

5.5 Conclusion

Pea hull fibre, when incorporated into baked products, can function to achieve fibre fortification. As many long term care facilities outsource baked products rather than preparing these products in-house, fibre fortification of potential outsourced baked products will be required for the successful implementation of insoluble fibre fortification of institutional diets. Prior to commercialization of fibre fortification, baking quality and sensory evaluation of commercial baked products fortified with pea hull fibre also will be required.

6. PREPARATION OF PUREED BREAD AND CEREALS AND THEIR INTAKE BY LONG TERM CARE RESIDENTS CONSUMING PUREED FOODS

6.1 Introduction

There are about 180 long term care units/facilities in the Province of Saskatchewan (Saskatchewan Health, 2002). A significant number of long term care residents displaying evidence of dysphagia are provided texture-modified foods to maintain or achieve normal food intake while reducing the risks of aspiration and choking (ADA, 2000). However, research has shown that pureed diets are sometimes ordered or requested for residents displaying psychological and behavioral problems or for staff convenience (Cluskey, 1989). About 16% of the long term care residents in Saskatchewan are offered pureed foods (Dahl & Zello, 2001). Although provincial long term care guidelines recommend that pureed foods should be prepared from usual regular menu items, and at a minimum should conform to Canada's Food Guide to

Healthy Eating (CFGHE) (Saskatchewan Health, 2002; OMOH, 1993), it is not known if foods offered on the pureed menu achieve this recommendation.

As described in Chapter 4, the addition of pea hull fibre to baked goods is an effective method of insoluble fibre fortification of long term care diets, and Chapter 5 provides evidence that baked products fortified with pea hull fibre have acceptable texture and sensory characteristics. However, baked goods and other cereal-based foods, perhaps the most appropriate foods for fibre fortification, are thought to be difficult to puree and may not be offered to dysphagic and other long term care residents consuming a pureed diet. Thus, strategies involving insoluble fibre fortification of baked goods may exclude those residents consuming a pureed diet. The objectives of this study were to determine the current grain-based food and total fibre intakes of long term care residents consuming pureed foods, and the frequency of facility preparation of grain-based pureed foods. It was hypothesized that grain-based foods such as breads are infrequently prepared and served to dysphagic long term care residents, and that intakes of cereal-based foods are below recommendations.

6.2 Methods

6.2.1 Survey of Preparation

A survey tool was developed to determine the frequency of preparation of six grain-based (termed 'high in starch') pureed foods and mailed to the seventy-nine long term care facilities in Saskatchewan. Respondents were asked to fax back survey results. If particular items were rarely prepared, respondents were asked to indicate the reason. Mashed (pureed) potatoes were also included in the survey, as it was thought that this food may be substituted for grain-based purees. **Appendix K** provides an example of the fax back survey.

6.2.2 Food Intake Assessment

Ethics approval for this investigation was received from the University of Saskatchewan Advisory Committee on Ethics in Human Experimentation (Biomedical Sciences) (**Appendix L**). Consecutive three- to five-day, mealtime pureed food intakes of twenty elderly, dysphagic residents living in two long term care facilities in Saskatoon, SK were assessed. Residents consuming pureed diets were chosen at random, and all names were coded to ensure confidentiality. Meals were plated by kitchen staff and individual portions of foods were weighed separately. Following meals, plates were returned to the kitchen or kitchenette and weights of leftover portions were determined. A record sheet was posted on each ward for the nursing staff to record any snacks given throughout the study period.

6.2.3 Nutrient Assessment

Typical pureed food processing was determined for each facility. The addition of liquids such as water, consommé, broth or gravy to pureed salads, vegetables, and meats were included in the nutrient analysis. The data were entered into Diet Analysis Plus, Version 5.1 (Wadsworth Publishing Company, 2001) for nutritional analysis. Foods equivalent or similar to those eaten by the residents during the study period were chosen from the database. For unique foods, such as combination salads or desserts, individual ingredients were entered into the database.

6.3 Results

6.3.1 Grain-based Pureed Food Preparation

Of the seventy-nine long term care facilities surveyed, thirty (42%) responded. Three of the respondents indicated that no pureed food production occurred in their facilities. The results of the survey are presented in **Table 6.1**. Cooked cereal was the most frequently served grain-based pureed food and was prepared once a day in 67% of responding facilities. For the majority of long term care facilities, pureed breads, pastas, pancakes, rice, cakes and cookies were either rarely (less than once a week) or never prepared, or prepared about once a week. Mashed potatoes were commonly offered in all long term care facilities.

6.3.2 Pureed Food Intake

Seventy-five days of dietary intakes were acquired in total. Results for apparent nutrient intake of pureed foods as well as nutrient contents of pureed foods offered are presented in **Table 6.2**. Energy intake was 1080 ± 197 kcal and fibre intake averaged 10.4 ± 3.8 g/day. Only 1.4 servings per day of grain products were consumed by individuals on pureed diets.

Cereal was the most common grain product served to dysphagic individuals receiving the pureed diet. The majority of long term care facilities did not include pureed breads as part of the pureed diet. Some respondents indicated never trying to puree bread, whereas others incorporated bread or toast softened in coffee, tea, warm milk or gravy in pureed diets for some residents. Most respondents indicated that cookies and cakes were not commonly pureed. Instead, desserts regularly served in the pureed diet were puddings, ice cream and canned fruit. Food services staff that did prepare cookies and cake for their dysphagic residents softened them in coffee or warm milk rather than pureeing them. Rice, pasta and pancakes were infrequently served to long term care residents receiving pureed foods. Pureed rice, when served, was most often served as part of a larger dish, such as a casserole or cabbage rolls. Respondents indicated that rice and pasta tended to be gooey or gummy when pureed on their own. Some had never attempted to puree these items, whereas others indicated that food service staff added warm milk to eliminate the gumminess of pureed rice and pasta. Regular pancakes softened with warm milk and syrup were part of some pureed menus. Concerns related to time constraints of staff and resistance to change were indicated as reasons for not preparing grain-based pureed foods.

Table 6.1. Frequency of preparation of pureed breads and cereals, and potatoes, in Saskatchewan long term care facilities (n = 30).

Pureed Food	Never Served (%)	Rarely Served (%)	Served weekly (%)	Served daily (%)	Served 2-3/day (%)	Not indicated (%)
Bread	12 (40)	4 (13)	1 (3)	12 (40)	1 (3)	0
Pasta	7 (23)	9 (30)	13 (43)	0	0	1 (3)
Rice	9 (30)	9 (30)	10 (33)	0	0	2 (7)
Cereal	7 (23)	1 (3)	2 (7)	20 (67)	0	0
Pancake	15 (50)	6 (20)	7 (23)	0	0	2 (7)
Potato	1 (3)	0	0	19 (63)	10 (33)	0
Cookie/cake	12 (40)	3 (10)	5 (17)	8 (27)	0	2 (7)

Table 6.2. Energy and macronutrient intakes of long term care residents consuming pureed food (n = 20).

Nutrient	Pureed Food Intake[a]
Energy Intake (kcal)	1074 ± 202
Water (g)	931 ± 205
Carbohydrate	141 ± 41
Protein (g)	54 ± 19
Fat (g)	35 ± 7
Fibre (g)	11.3 ± 6.2

[a] mean ± SD

6.4 Discussion

The results demonstrate that grain products appear infrequently on pureed food menus and at a rate less than the five to eleven servings per day recommended in Canada's Food Guide to Healthy Eating (Health Canada, 1990). The lack of pureed grain-based foods prepared by long term care facilities and thus, consumed by long term care residents offered pureed foods is a concern. Instead, mashed potatoes are offered at least once a day. Although mashed potatoes are easy to prepare and visually balance pureed meals, potatoes do not replace the nutrients provided by bread, pasta and rice. The frequent offering of mashed potatoes also contributes to a lack of variety in the residents' diets and would limit fibre fortification unless potatoes and other pureed foods were fortified with fibre.

A number of factors may have affected the reliability of the pureed food intake data. Although data sheets for recording residents' snacks were provided to dietary staff, they were not used at all in one facility. It is uncertain, in this case, whether no snacks were given or if the snacks were not recorded. A significant amount of uneaten pureed food was not recovered for weighing, due to ineffective assistance with eating and residents spitting out the food. Thus, the fibre intake reported may be higher than actual intakes. Alternatively, the staff and volunteers that assist with eating may have been making an extra effort to assist the residents with eating as they were aware that intake data was being recorded. Although for the purposes of this study dining assistants were specifically asked not to mix foods together, on occasion foods were mixed together which made it difficult to obtain an accurate weight of individual portions of the leftovers. It is not known if mixing of pureed foods is a common occurrence in the facilities, and if so, whether this procedure affects the acceptability and intake of pureed foods.

The results of the pureed food intake analysis indicate that the intakes of grain-based pureed foods by dysphagic residents on pureed diets in long term care facilities were inadequate. The fibre intakes of the residents consuming pureed foods were well below the recommended intakes of 21 g/day and 30 g/day for elderly women and men, respectively (IOM, 2002).

6.5 Conclusion

This study demonstrated that residents in long term care facilities on pureed diets would receive little benefit from fortification of cereal-based foods with insoluble fibre, as residents offered a pureed diet consumed only 1.4 servings of grain products per day. The fibre intake of dysphagic residents may need to be improved by fortifying a variety of pureed foods with insoluble fibre. However, fibre fortification of pureed menus may require menu modification, product development, standardized recipes and the use of appropriate processing equipment. The overall nutritional inadequacy of the pureed menu must also be addressed.

7. ASSESSING THE TEXTURAL CHARACTERISTICS OF PUREED FOODS

7.1 Introduction

The data presented in Chapter 6 suggest that long term care residents consuming pureed foods would not benefit fully from insoluble fibre fortification of the regular diet as these individuals receive few grain-based foods, the target food vehicles for fibre enhancement. As the fibre intakes of long term care residents consuming pureed foods were less than 50% of recommended levels, fibre fortification of typically-consumed pureed foods is required for fibre intakes to be adequate. However, as appropriate textural characteristics of pureed foods are required for successful swallowing by dysphagic individuals, objective standards for target textural characteristics are required for the development of pureed foods fortified with insoluble fibre and for pureed food production in general. Dietary management strategies for many dysphagic conditions recommend moist, semi-solid foods that can maintain a cohesive bolus (ADA, 2000). Current therapeutic diet standards have responded to this requirement with recommendations that a pureed food should have a spoon-thick or pudding-like consistency, be thick and homogenous, and have no coarse textures (ADA, 2000). The report of the National Dysphagic Diet Task Force indicates that any foods requiring bolus formation, controlled manipulation and/or mastication should be excluded from the dysphagia pureed diets (ADA, 2002).

Food texture is defined as "that group of textural characteristics that arise from the structural elements of the food, are sensed primarily by the feeling of touch, are related to deformation, disintegration and flow of the food under a force, and are measured objectively by functions of mass, time and distance" (Borne, 2002). Of the textural characteristics identified as most significant in dysphagia management by the U.S. National Dysphagic Task Force, pureed foods possess viscosity, cohesiveness, adhesiveness, hardness and yield stress. Size of particles has also been suggested as a textural characteristic that should be considered in dysphagia management (Ordre des diététistes due Quebec, 2000).

Although standard objective methods are used to assess commercial foods such as applesauce, creamed corn and catsup (3), no such methods and standards have been recommended to evaluate the textural characteristics of pureed foods for dysphagic management. The objectives of this study were to assess the validity of the Bostwick Consistometer, the line spread test and a spoon-thickness test for the prediction of viscosity, to determine the suitability of the wet sieve method of particle size analysis for pureed foods, and to determine if the objective measurements of hardness, cohesiveness and adhesiveness were suitable for the evaluation of pureed foods with a wide range of textural characteristics.

7.2 Methods

Samples of pureed foods from two long term care facilities, a commercially-produced pudding and other puree-consistency foods were analyzed in duplicate for viscosity, consistency and particle size, and commonly available, commercially-produced, puree-consistency foods were analyzed for adhesiveness, cohesiveness and hardness. Viscosity was determined using a Brookfield Viscometer (Model DV-111, Brookfield Engineering Laboratories, Inc.). Each 400 mL sample of pureed food was placed in a 600 mL beaker and heated in a water bath to 55°C. Viscosity measurements were taken with spindle #5 at 5 rpm. Percent torque and viscosity were recorded for each sample.

Consistency was determined with a Bostwick Consistometer (Canadawide Scientific, Ottawa, ON). Pureed food samples and the Consistometer were heated to 55°C in a water bath. The compartment was filled with the pureed food to be tested and leveled. The trigger was pressed, releasing the gate and allowing the food to flow into the second compartment. The distance (cm) traveled by the pureed food in 30 sec was determined. Consistency was also assessed using the line spread test. A 50 mL sample of pureed food was placed in a hollow stainless steel tube. The tube was positioned in the center of a plastic sheet covering a sheet of paper on which were printed concentric rings ranging from 0-25 cm in diameter. The tube was lifted and the food sample was allowed to disperse for 30 sec. The distance (cm) traveled at each 90° angle was recorded and the average of the four measurements was calculated.

Consistency was also assessed by a spoon-thickness test. Teaspoons were obtained from local long term facilities. The weights of heaping teaspoons of the commercial and institutional pureed foods were measured in triplicate. The pureed food was spooned from the container, and any excess food adhering to the lower surface of the spoon was removed by scraping the spoon three times on the edge of the container prior to weighing.

Particle size distribution was determined by a modification of the wet sieving procedure outlined by Sefa-Dedeh (1989). Pureed samples (50 g) were washed with a continuous spray of tepid tap water for 2 min through sieves of 16 mesh (1.0 mm), 20 mesh (850 μm), 28 mesh (600 μm), 48 mesh (300 μm) and 65 mesh (212 μm). The solids left on each sieve were collected on Whatman #4 filter paper and dried to constant weight at 100°C. The quantity of solids that passed through the finest sieve was determined by difference. The data for residue on the 20, 28 and 48 mesh were grouped. Details of the particle size analyses are included in **Appendix M**.

Adhesiveness, cohesiveness and hardness were assessed with a Texture Profile Analyzer (TPA) (Model TMS 2000, Food Technology Corporation) equipped with a 250 pound transducer. The piston speed was set at 0.33 cm/sec, the pressure was set to 1400 Kpa, the percentage of compression was 70%, and the height of the sample in the container was 5 cm. All foods were assessed in duplicate at 20-23°C.

Correlations were determined among Consistometer readings, line spread test measurements, spooned weights and viscosities. The significance of the correlation was determined using a paired t-test. Single sample t-tests were performed on 16 mesh residues to compare the particle sizes of institutional and commercially-prepared pureed foods to a target value of zero.

7.3 Results

The results of viscosity and consistency analysis of pureed foods are presented in **Table 7.1**. The viscosities of the commercial pureed foods ranged from 8,040 to 40,620 cP. Many of the pureed foods prepared at the two institutions were too viscous for viscosity determination. There was no significant correlation between viscosity and consistency, nor between viscosity and line spread ($r = -0.27$; $p > 0.05$ and $r = -0.47$; $p > 0.05$, respectively). **Table 7.2** gives the viscosity and spooned weight of various pureed foods. There was a significant positive relationship between spoonful weight and viscosity of pureed foods ($r = 0.67$) ($p<0.001$).

Particle size analysis (**Table 7.3**) revealed that an average of 23.9% and 1.1% of the solid particles in institutional and commercial pureed foods, respectively, did not pass through a 16 mesh screen and, therefore, exceeded 1 mm in size, whereas none of the solid particles in commercial puddings exceeded 1 mm. An average of 85% (range = 47.1 - 97.1%) of the commercial pureed foods and 52% (range = 21.6 - 85.5%) of the institutional pureed foods passed through the finest sieve (65 mesh). The average residue of institutional and commercial pureed foods exceeding 1 mm differed significantly from zero. However, the difference for the commercial pureed foods was insignificant for practical purposes. Detailed particle size analysis is presented in **Appendix M**.

The parameters of hardness, adhesiveness and cohesiveness were determined for all commercial pureed foods (**Table 7.4**). Hardness values ranged from 0.0 N for fruit purees to 110.6 N for cream cheese. Adhesiveness ranged from 15.3 N·m for applesauce to 50.8 N·m for peanut butter. Cohesiveness ranged from 3.7 for vanilla pudding to -4.0 for tomato paste.

Table 7.1. Viscosity, consistency and line spread of pureed foods (n=2).

Pureed Food Item (Testing Temperature)	Viscosity (cP)	Consistency (cm/30 sec)	Line Spread (cm/30 sec)
Vanilla pudding[a] (22°C)	28327 ± 514	1.8	1.8
Vanilla cooked pudding[b] (4°C)	14107 ± 928	1.4	2.1
Vanilla cooked pudding[b] (22°C)	11767 ± 1101	3.0	2.7
Apple sauce[c] (4°C)	12133 ± 521	2.4	2.8
Apple sauce[c] (22°C)	9640 ± 332	3.3	2.9
Stirred yogurt[d] (4°C)	7872 ± 23	8.2 ± 0.6	3.4 ± 0.2
Commercial[e] beef (55°C)	8040 ± 69	1.8 ± 0.0	1.9 ± 0.2
Commercial[e] squash (55°C)	11914 ± 217	6.8 ± 0.3	3.0 ± 0.0
Commercial[e] peas (51°C)	28534 ± 754	0.6 ± 0.1	1.4 ± 0.5
Commercial[e] egg/toast (51°C)	18034 ± 644	0.8 ± 0.1	1.3 ± 0.5
Commercial[e] carrot (55°C)	40620 ± 84	0.4 ± 0.1	1.0 ± 0.0
Commercial[e] chicken (55°C)	40280 ± 1018	3.4 ± 0.2	2.5 ± 0.2
Commercial[e] beef stew (55 °C)	23026 ± 358	2.9 ± 0.0	2.2 ± 0.6
Institutional[e] peas (50°C)	12138 ± 177	0.5 ± 0.0	1.1 ± 0.6
Institutional[e] carrots (55°C)	8000 ± 88	1.3 ± 0.4	2.9 ± 0.2
Institutional[e] chili (55°C)	10914 ± 839	1.2 ± 0.2	1.9 ± 0.1
Institutional[e] beef (50°C)	---	0	0.1 ± 0.0
Institutional[e] potato (55°C)	---	0	0
Institutional[e] pork (55°C)	---	0	0
Institutional[e] chicken (53°C)	---	0	0

Institutional[e] turkey (52°C)	---	0	0

[a] Jello® Vanilla Pudding, Individual portions.
[b] Jello® Vanilla Pudding and Pie Filling.
[c] Safeway® Unsweetened Apple Sauce.
[d] No Name® plain yogurt.
[e] Private Recipe® Limited pureed food, Brampton, Ontario, Canada.
[f] Pureed institutional food.

Table 7.2. **Spooned weight (g) (n = 3) and viscosity (cP) (n = 2) of pureed foods.**

Pureed Food	Viscosity (cP)	Spooned Weight (g)
Apricots 1	8667 ± 38	12.2 ± 0.5
Apricots 2	9613 ± 57	12.4 ± 1.1
Beef 1	12253 ± 584	15.7 ± 1.3
Beef 2	3113 ± 283	17.6 ± 0.2
Beef Stew 1	7560 ± 434	15.2 ± 0.8
Beef Stew 2	11267 ± 509	15.4 ± 0.1
Carrots 1	14640 ± 452	19.9 ± 1.8
Carrots 2	15360 ± 528	20.5 ± 1.0
Chicken 1	26813 ± 1565	25.9 ± 3.2
Chicken 2	20187 ±	20.0 ± 0.6
Chicken Casserole	14627 ± 773	16.6 ± 2.2
Fruit Cocktail	9960 ± 94	11.0 ± 0.4
Gravy 1	6020 ± 2008	15.1 ± 0.7
Gravy 2	7863 ± 75	12.6 ± 0.3
Green/Yellow Beans	5867 ± 415	18.4 ± 1.6
Green Beans	4947 ± 245	10.9 ± 0.9
Meat Sauce 1	8240 ± 263	14.9 ± 0.3
Meat Sauce 2	7360 ± 377	13.7 ± 1.9
Meatloaf	12534 ± 377	10.8 ± 1.1
Mixed Vegetables	8880 ± 379	15.2 ± 0.2
Peaches	4880 ± 0	11.2 ± 0.2

Pears 1	5067 ± 6	12.6 ± 0.3
Pears 2	4587 ± 38	12.3 ± 0.7
Peas 1	18387 ± 886	21.5 ± 1.0
Peas 2	14907 ± 328	13.2 ± 0.7
Peas and Carrots 1	20573 ± 471	14.2 ± 1.9
Peas and Carrots 2	13653 ± 566	17.7 ± 1.0
Pork	19173 ± 792	18.8 ± 1.0
Shepherd's Pie	25706 ± 114	17.4 ± 0.4
Squash 1	22947 ± 132	21.5 ± 2.9
Squash 2	7613 ± 245	13.7 ± 1.9
Turkey	7307 ± 528	18.2 ± 0.7

Table 7.3. Percentage of residue (dry weight basis) retained on sieves of various mesh sizes (n = 2).

Pureed Food	% of pureed food residue after sieving		
	Mesh 16	Mesh 20, 28, 48	Mesh 65
Commercial [a] pudding	**0.0**	**0.0**	**100.0**
Institutional [b] potato	18.7	45.9	35.4
Institutional [b] beef	1.6	12.9	85.5
Institutional [b] pea	57.3	6.2	36.5
Institutional [b] turkey	58.2	20.2	21.6
Institutional [b] pork	2.5	49.4	48.1
Institutional [b] chicken	27.5	16.1	56.4
Institutional [b] carrots	7.3	35.2	57.5
Institutional [b] pork chop	22.7	15.5	61.8
Institutional [b] chili	8.7	27.5	63.8
Institutional [b] turkey(2)	34.6	12.2	53.2
Commercial [c] ham	0.2	11.5	88.3
Commercial [c] turkey	0.8	20.9	78.3
Commercial [c] chicken	0.2	4.8	95.0
Commercial [c] pork	2.0	27.8	70.2
Commercial [c] broccoli	1.3	11.2	87.5
Commercial [c] carrot	0.0	13.1	86.9
Commercial [c] squash	4.5	48.4	47.1
Commercial [c] turnip/apple	0.9	12.0	87.1

Commercial [c] peas	0.4	12.3	87.3
Commercial [c] vegetables	1.9	9.7	88.4
Commercial [c] creamed salmon	0.2	4.3	95.5
Commercial [c] shepherd's pie	1.5	23.8	74.7
Commercial [c] vegetarian lasagna	0.3	2.8	96.9
Commercial [c] macaroni & cheese	0.3	2.6	97.1
Commercial [c] fish	0.7	9.6	89.7
Commercial [c] spaghetti	0.6	12.1	87.3

[a] Jello® vanilla pudding, individual portions
[b] Blenderized institutional foods.
[c] Private Recipe® Limited, Brampton, Ontario, Canada.

Table 7.4. Hardness, cohesiveness and adhesiveness of commercial food products of puree consistency (n = 2).

Food Product	Hardness (N)	Cohesiveness	Adhesiveness (N·cm)
Vanilla Pudding	4.5 ± 0.0	3.7 ± 2.1	27.0 ± 3.1
Lemon Pudding	5.2 ± 1.0	0.7 ± 2.7	19.2 ± 0.9
Apple Sauce	2.2 ±1.5	1.4 ± 0.0	15.3 ± 1.0
Plain Yogurt	1.5 ± 0.0	1.3 ± 0.1	15.5 ± 1.0
Peanut Butter	66.7 ± 4.1	0.0 ± 0.1	50.8 ± 0.5
Cream Cheese	110.6 ± 3.2	0.0 ± 0.0	46.8 ± 2.8
Fine Liver Sausage	92.8 ± 3.1	0.0 ± 0.0	45.3 ± 0.5
Nutella	48.2 ± 7.3	0.2 ± 0.4	36.2 ± 1.5
Pure Pumpkin	18.5 ± 1.1	-0.3 ± 0.1	35.2 ± 0.6
Cream Cheese spread	65.3 ± 4.2	0.0 ± 0.1	34.4 ± 0.4
Tomato Paste	5.9 ± 0.0	-4.0 ± 11.2	30.3 ± 1.0
Pumpkin Pie Filling	8.9 ± 0.0	-1.1 ± 0.4	29.3 ± 0.1
Mayonnaise	18.5 ± 1.1	-0.2 ± 0.1	26.1 ± 1.3
Fruitsations®	0.0 ± 0.0	1.4 ± 0.2	20.9 ± 2.5
Tomato Sauce	-2.2 ± 1.0	1.0 ± 0.1	17.5 ± 2.5
Pea soup/ham/pureed	-2.2 ± 1.0	1.0 ± 0.0	15.7 ± 0.7
Instant mashed potato	59.3 ± 0.1	0.0 ± 0.0	46.3 ± 0.5
Cream of Wheat	75.6 ± 33.5	0.1 ± 0.0	48.6 ± 4.4
Chick pea puree	12.6 ± 1.1	-0.4 ± 0.1	21.4 ± 0.6

7.4 Discussion

The results of this investigation provide evidence that the textural characteristics of pureed foods can be assessed using quick, simple methodology. The Brookfield Viscometer requires a significant financial investment, is labor intensive and, therefore, not a feasible option for quality control of pureed food in many institutions. However, a simple, fast, yet sensitive tool for viscosity and consistency testing of institutionally pureed foods is needed to ensure textural quality. The Bostwick Consistometer is used to assess the consistency of fruit and vegetable purees such as applesauce, baby foods and tomato catsup (Borne, 2002), but lacked sufficient precision in assessing the consistency of pureed foods in this study, particularly highly viscous foods. It has been suggested that the line spread test can be used to assess the viscosity of pureed foods (Mann & Wong, 1996), but this tool also lacked accuracy. Furthermore, the line spread test (also known as the slump test) is designed to estimate yield stress (Borne, 2002) rather than viscosity. The spoon-thickness test provided a suitable predictor of viscosity and could be used to assess more viscous pureed foods. However, assessment of spooned weight or volume may not be appropriate for foods with a high level of air incorporation, such as mousses. As most pureed foods are high in water content, the ratio of spooned weight to volume is near one, thus spoon-thickness volume may also be an appropriate assessment method. As it is recommended that an appropriate bolus size for an effective swallow in dysphagic individuals should exceed 7.5 mL (ADA, 2000), spoon-thickness volume may be an appropriate indicator of which pureed foods are too thin to deliver the appropriate bolus size by spoon.

The wet sieve method of particle size assessment of pureed foods distinguished between institutionally-prepared pureed foods and commercially-prepared homogenized pureed foods. The 16 mesh sieve may be the most appropriate tool for quality control of particle size, as pureed food residue of particle size greater than 1 mm would be retrained.

As hardness, adhesiveness and cohesiveness are important textural characteristics in the management of dysphagia, consideration should be given to whether pureed foods intended for this population should be assessed for these characteristics. The puree-consistency foods varied widely in hardness, adhesiveness and consistency. Notably, mashed potatoes, which are commonly served to dysphagic individuals, had an adhesiveness value of 46.3 N·m, near that of peanut butter, a food contraindicated in a diet for the management of dysphagia (ADA, 2002).

The findings indicate that institutionally-prepared pureed foods exhibit a wide range of textural characteristics. The development of objective measurements to describe the textural characteristics of pudding-like or spoon-thick consistency, such as the spoon-thickness test and the wet sieve method for particle size determination, may reduce subjectivity and function to provide quality control of pureed food production in institutions. Furthermore, the suitability of institutional equipment for the production of pureed foods and appropriate methods for pureed food production require investigation. Texture Profile Analysis is appropriate for the testing of a wide variety of pureed foods and may be applicable for product development and quality control of commercial pureed food production.

The importance of textural characteristics in pureed foods for the management of dysphagia supports the need for objective textural measurements appropriate for institutions and commercial producers. The line spread test and consistometer, although tools that may be appropriate for the assessment of thickened beverages, are not appropriate for the assessment of pureed foods. Consensus on appropriate methods for the textural analysis and quality control of pureed food production is needed.

7.5 Conclusion

The development of pureed foods fortified with insoluble fibre may require the assessment of a number of textural characteristics using various methodologies. Viscosity and, possibly, consistency methods may be used to ensure appropriate viscosity and the achievement of a pudding consistency. Although Texture Profile Analyzer can be used to assess to determine hardness, adhesiveness and cohesiveness of pureed food, no recommended target values or ranges for these textural parameters have been outlined.

8. DEVELOPMENT AND CHARACTERIZATION OF PUREED FOODS FORTIFIED WITH PEA HULL FIBRE

8.1 Introduction

No evidence exists suggesting that total fibre intakes of individuals residing in long term care facilities should differ from the recommendations of 21 g/day for elderly women and 30 g/day for elderly men (IOM, 2002). However, food intakes of long term care residents, particularly those with dysphagia, are compromised (Nozaki, Saito, Matsumura, Miyai & Kang, 1999), and supplemental fibre may be required to meet fibre recommendations (ADA, 2002).

As described in Chapter 6, fibre intakes of dysphagic long term care residents are inadequate and grain-based foods, ideal for fibre enhancement, are not commonly prepared. In addition, fibre-containing foods such as whole grain breads and cereals are difficult to puree. To achieve fibre recommendations, fibre fortification of multiple pureed foods may be required. Five to ten servings of foods containing 2-4 g of dietary fibre would be needed to ensure that individuals with dysphagia meet fibre recommendations. Although some commercial pureed foods are fortified with fibre, no known research on fibre fortification of pureed foods has been published.

Fibre-fortified pureed foods available commercially in Canada use soy cotyledon fibre as a fibre source. As soy cotyledon fibre is mostly soluble (Lo, 1989) and is subject to extensive fermentation, its effect on fecal bulking is limited (Cummings, 1993). Finely processed pea hull fibre, containing mostly insoluble fibre, may be a more appropriate fibre source for fortification of pureed foods, as it will function to provide significant fecal bulking. It is not known if the replacement of soy cotyledon fibre with pea hull fibre will result in discernable texture or taste difference in pureed foods. The objectives of this study were to evaluate the sensory characteristics of texturally-appropriate pureed beef, potato, carrot and beef stew fortified with pea hull fibre, and to determine if there were detectable taste or texture differences between commercial formulations of pureed foods fortified with soy cotyledon fibre and pureed foods containing pea hull fibre.

8.2 Methods

8.2.1 Analysis of Texture

Pureed beef, potato, carrot and beef stew were fortified with 2 g/serving of soy cotyledon fibre (Fibrim®, Protein Technologies International, St. Louis, MO) or 2 g/serving of pea hull fibre (Centara III®, Parrheim Foods, Portage la Prairie, MB). The formulations for the pureed potato, carrot, beef and beef stew are considered to be proprietary information by Private Recipes Limited, Brampton, ON; these foods are not altered or unusual in any way that would prevent the data from being extrapolated to other pureed foods. Foods were processed at 2500 rpm for twenty seconds, 5000 rpm for twenty seconds and at 7500 for twenty seconds in a Braun CombiMax 600 (GM 200 Retsch Grindomix). Thirty-gram samples were placed in small plastic containers and frozen at -20°C. Twenty-seven hours prior to sensory evaluation, the samples were removed from the freezer and thawed at 2°C. Samples were then heated at 60°C for thirty-five minutes, and then placed in an incubator at 65°C for ten minutes. In addition, three hours prior to the sensory evaluation session, 60 mL porcelain cups, intended to retain heat during sensory evaluation, were warmed in the oven at 55°C. The three samples to be evaluated were served simultaneously.

Methods for viscosity, consistency, particle size, adhesiveness and hardness analysis are described in Section 7.2. All assessments were done in duplicate.

8.2.2 Sensory Evaluation

8.2.2.1 Recruitment of Sensory Panelists

Ethics approval for the sensory evaluation of fibre-fortified pureed foods was received from the University of Saskatchewan Biomedical Research Ethics Board (**Appendix N**). The consent form is included in **Appendix O.** University of Saskatchewan staff and students were recruited to serve as untrained sensory panelists. Twenty-four volunteers (aged 18-50 years) were screened prior to participation by means of a self-administered questionnaire (**Appendix P**). No volunteers indicted smoking, pertinent food allergies or a dislike for pertinent textures. Therefore, none were excluded from participation. Each panelist was required to complete four sensory evaluation sessions.

8.2.2.2 Sensory Evaluation Conditions

The sensory evaluation room consisted of seven booths, and was adjacent to the preparation area. The temperature of the sensory evaluation room was maintained at 22°C. Possible colour differences among the samples were masked by the use of dimmed light (1 lux). The tables, chairs and walls of the sensory evaluation room were neutral in color, non-odorous and clean.

8.2.2.3 Sample Presentation

Samples were served at 55°C in plastic 30 mL containers placed in 60 mL white porcelain containers. The quantity of sample served and considered representative of the product was 40 g. Three-digit random numbers were assigned to each food sample. The order of presentation also was randomized and presented an equal number of times. All panelists were given tap water at room temperature for oral rinsing between samples, and panelists were instructed to rinse between samples. Panelists were allowed to sample the products at their own pace.

8.2.2.4 Triangle Test

To determine if there was a detectable difference between pureed foods containing soy cotyledon fibre and pea hull fibre, a triangle test was undertaken. In each session, panelists were required to complete a triangle test on two types of pureed food. Beef, potato, carrot and beef stew purees containing soy cotyledon fibre and pea hull fibre were evaluated. The panelists received three randomly coded samples, and were told that two of the samples were the same and one was different. Panelists were then asked to taste the samples in the order presented, using a clean spoon for each sample, and then to identify the sample perceived to be different on the sheet provided. Panelists also were asked to indicate in what respect the identified sample was different.

8.2.2.5 Statistical Analysis

With the triangle test, it is expected that the odd sample will be selected by chance one-third of the time. Significant results of the triangle test would indicate whether a detectable difference existed between samples prepared with the different fibre sources. The null hypothesis of each triangle test was that there was no difference between samples containing either pea hull fibre or soy cotyledon fibre. The level of significance (α) was set at 0.05. The number of correct responses required for significance beyond chance is dependent on the sample size and can be determined by the binomial law. Higher levels of significance do not indicate that a difference is greater, but instead that there is a greater probability of a real difference.

Viscosities of pureed foods were compared to the target viscosity of 24,000 cP using a one-sample t-test.

8.2.2.6 Descriptive Sensory Analysis

Panelists ($n = 6$) who selected the most correct responses in the triangle test were asked to participate in descriptive sensory analysis. Ballots with specific descriptive terms based on current literature were developed. One hour of descriptive training was carried out with each panelist. See **Appendix Q** for an example of the descriptive sensory evaluation. Paired t-tests using the Bonferroni correction to level significance were carried out for each descriptive characteristic of each of the four pureed foods. Factors were found to be significant were those with $p < 0.008$.

8.3 Results

8.3.1 Analysis of Texture

Table 8.1 presents the viscosities of pureed beef, potato, carrot and beef stew fortified with pea hull fibre or soy cotyledon fibre at serving temperature (55°C). The target viscosity of each pureed food system was 24,000 cP. **Table 8.2** provides the hardness and adhesiveness of pureed foods fortified with pea hull fibre at room temperature and at serving temperature. The adhesiveness and hardness of the pureed foods were not different than the pudding standards of 27.0 N·cm and 4.5 N, respectively. Pureed beef stew most closely resembled the cohesiveness of the pudding standard.

Table 8.1. Viscosities of beef, potato, carrot and beef stew pureed foods fortified with pea hull fibre or soy cotyledon fibre (n=4) at about 50-55°C.

Pureed Food (fibre source)	Viscosity (cP)
Beef (pea)	24009 ± 1056
Beef (soy)	24580 ± 225
Potato (pea)	23280 ± 859
Potato (soy)	24073 ±338
Carrot (pea)	26220 ± 793
Carrot (soy)	24007± 224
Stew (pea)	24060 ± 504
Stew (soy)	24180 ±183

Table 8.2. Hardness, cohesiveness, and adhesiveness of beef, potato, carrot and beef stew pureed foods fortified with pea hull fibre.

Pureed Food (temperature)	Hardness (N)	Cohesiveness	Adhesiveness (N.cm)
Vanilla Pudding	4.5 ± 0.0	3.7 ± 2.1	27.0 ± 3.1
Beef (23C)	7.4 ± 0.0	-5.6 ± 1.6	29.2 ± 0.3
Beef (54C)	1.5 ± 0.0	1.4 ± 0.2	22.4 ± 1.5
Potato (21C)	9.7 ± 1.0	-1.2 ± 1.0	27.7 ± 0.6
Potato (54C)	3.0 ± 0.0	1.3 ± 0.2	23.1 ± 0.8
Carrot (20C)	0.0 ± 0.0	1.6 ± 0.2	29.2 ± 0.2
Carrot (54 C)	1.5 ± 0.0	2.1 ± 0.1	27.2 ± 0.1
Stew (21C)	14.8 ± 0.0	-0.8 ± 0.0	31.6 ± 0.3
Stew (53 C)	3.7 ± 1.1	3.4 ± 2.7	25.0 ± 4.1

8.3.2 Sensory Evaluation

Table 8.3 contains the results of the triangle test. The results indicate that there were detectable differences between the pureed potato, carrot and beef stew fortified with pea hull and the corresponding products fortified with soy cotyledon fibre. No detectable difference was found between pureed beef prepared with pea hull fibre or soy cotyledon fibre.

The results of the descriptive sensory analysis are presented in **Table 8.4**. No significant differences in the rankings of textural attributes of pureed foods were found, except for residual particles beef and carrot mouthcoating for beef and beef stew. Carrot was found unacceptable by some panelists with comments regarding the grittiness of pureed carrot.

Table 8.3. Summary of triangle test to determine discrimination between pureed beef, potato, carrot and beef stew fortified with pea hull fibre or soy cotyledon fibre.

Pureed Food	Total	Correct	Incorrect	Probability
Potato S-P-P[1]	21	10	11	NS
Potato P-S-S[2]	16	9	7	P < 0.05
Total Potato	37	19	18	P < 0.01
Beef S-P-P	15	8	7	NS
Beef P-S-S	21	8	13	NS
Total Beef	36	16	20	NS
Carrot S-P-P	21	11	10	P < 0.05
Carrot P-S-S	20	9	11	NS
Total Carrot	41	20	21	P < 0.05
Beef stew S-P-P	20	10	10	NS
Beef stew P-S-S	21	8	13	NS
Total Beef stew	41	18	23	P < 0.05

[1] S-P-P indicates that one sample with soy fibre and two samples with pea hull fibre were presented in random order.
[2] P-S-S indicates that one sample with pea hull fibre and two samples with soy fibre were presented in random order.

Table 8.4. Ranking of descriptive sensory characteristics of pureed foods fortified with pea hull fibre.

Attribute	Beef	Potato	Carrot	Beef stew
Aroma Rank [a]	4.0 ± 0.7^{a}	2.5 ± 0.7^{a}	2.6 ± 1.1^{a}	3.7 ± 1.2^{a}
Aroma Acceptance	83%	100%	66%	100%
Flavour Rank [b]	3.5 ± 0.5^{a}	2.4 ± 0.8^{a}	2.3 ± 0.6^{a}	4.0 ± 0.5^{a}
Flavour Acceptance	100%	83%	66%	100%
Adhesion [c]	3.6 ± 0.5^{a}	3.7 ± 0.4^{a}	2.5 ± 1.1^{a}	2.9 ± 0.8^{a}
Cohesion [d]	2.5 ± 0.9^{a}	3.2 ± 0.8^{a}	2.0 ± 1.1^{a}	2.4 ± 0.5^{a}
Particles [e]	2.5 ± 0.9^{a}	1.4 ± 0.6^{a}	1.2 ± 0.4^{a}	1.8 ± 0.9^{a}
Particle size [f]	2.0 ± 1.1^{a}	1.2 ± 0.4^{a}	1.2 ± 0.4^{a}	1.6 ± 0.8^{a}
Smoothness [g]	2.6 ± 0.7^{a}	1.3 ± 0.5^{a}	1.4 ± 0.8^{a}	1.9 ± 0.7^{a}
Viscosity [h]	3.3 ± 0.6^{a}	4.2 ± 0.5^{a}	3.1 ± 0.8^{a}	3.3 ± 0.6^{a}
Dryness [I]	2.3 ± 0.5^{a}	2.8 ± 0.7^{a}	2.8 ± 0.7^{a}	2.7 ± 0.8^{a}
Residual Particles [j]	2.5 ± 0.8^{a}**	1.5 ± 0.4^{ab}	1.4 ± 0.5b**	2.0 ± 0.9^{ab}
Mouth coating [k]	3.8 ± 0.8^{a}**	3.4 ± 0.6^{ab}	3.0 ± 0.7^{ab}	2.7 ± 0.6^{b}**

[a] Aroma: 1 = not detectable; 5 = clearly detectable
[b] Total flavour intensity: 1 = no flavour; 5 = strong flavour
[c] Adhesiveness: 1 = not adhesive; 5 = very adhesive
[d] Cohesiveness (holds together): 1 = non cohesive; 5 = very cohesive
[e] Amount of particles: 1 = none; 5 = a lot
[f] Particle size: 1 = very fine; 5 = coarse
[g] Smoothness: 1 = smooth; 5 = lumpy
[h] Viscosity: 1 = thin; 5 = thick
[i] Drying of mouth: 1 = mouth feels dry; 5 = mouth feels moist
[j] Amount of Particles: 1 = none; 5 = a lot
[k] Mouth coating: 1 = none; 5 = heavy

** Significantly different at $p < 0.01$

8.4 Discussion

The results of this investigation indicate that pea hull fibre can be incorporated into beef, potato, carrot and beef stew at a level of 2 g/125 mL serving while achieving hardness and adhesiveness resembling 'pudding' consistency. In addition, the target viscosity of 24,000 cp was achieved in pureed foods fortified with pea hull fibre. However, during sensory evaluation, some panelists were able to distinguish between soy cotyledon fibre and pea hull fibre in potato, carrot and beef stew, but not in beef. The most commonly cited reason for a difference was texture, with some indicating grittiness with pea hull fibre. It may be possible to eliminate the grittiness by reducing further the particle size of pea hull fibre.

Further sensory analysis was undertaken to evaluate aroma, flavour, adhesiveness, cohesiveness, amount of particles, particle size, smoothness/ lumpiness, bolus viscosity, drying of the mouth, amount of residual particles and mouth coating. Potato and beef stew purees were rated as highly acceptable. Beef and beef stew were ranked higher in flavour than were carrot and potato. It is not known whether these attributes are characteristic of pureed foods in general. Further investigation is required to determine if the sensory characteristics exhibited by the pureed foods fortified with pea hull fibre are acceptable for dysphagic individuals and would function to aid swallowing.

8.5 Conclusion

Pureed beef, potato and beef stew were acceptable when fortified with 2 g of pea hull fibre/serving. However, the substitution of soy cotyledon fibre with pea hull fibre in pureed foods resulted in detectable textural differences. Further investigation is required to determine if the sensory characteristics exhibited by the pureed foods fortified with pea hull fibre are acceptable to dysphagic individuals and would function to aid swallowing.

9. VISCOSITY BEHAVIOUR OF PUREED FOODS FORTIFIED WITH FIBRE

9.1 Introduction

The provision of sufficient dietary fibre in the diets of people with dysphagia is a significant challenge. Fortification of pureed foods with fibre offers a possible solution. However, commercial pureed foods that contain added fibre often use soluble fibre sources, and modified starch is used to achieve appropriate viscosity in both commercial and institutional pureed foods. Although soluble fibre and modified starch offer food functionality, these ingredients do not offer an appropriate nutritional advantage for long term care residents consuming pureed foods. Soluble fibre promotes little laxation and may contribute to flatulence, bloating and discomfort. Modified starch is generally not significantly enzyme resistent and offers no marginal nutrients. The addition of insoluble fibre to pureed foods may have the advantage of offering both food functionality, such as viscosity enhancement, and significant fecal bulking to consumers of the pureed food, specifically long term care residents who have dysphagia.

As reported in Chapter 8, the addition of an insoluble fibre ingredient, namely pea hull fibre, at 2 g/125 g serving enabled the production of pureed foods having recommended viscosity, hardness and adhesiveness, as well as sensory acceptability. As pureed foods prepared for dysphagic individuals are recommended to have a spoon-thick or pudding-like consistency, to be thick and homogenous and to have no coarse textures, fortification with insoluble fibre ingredients may function to achieve pureed foods with these recommended textural characteristics. Characterization of the viscosity of fibre-fortified pureed foods is required for pureed food product development and testing. If it could be shown that pureed foods fortified with insoluble fibre are functional and stable, and that the viscosity behaviour of insoluble-fibre-fortified pureed foods resemble that of the pudding-like standard, the appropriateness of these foods for dysphagic individuals would be assured.

The objectives of this investigation were to describe the viscosity characteristics of pureed foods (vegetable, meat, starch and casserole) fortified with microcrystalline cellulose or soy cotyledon fibre, and to determine the effect of incremental levels of microcrystalline cellulose on the viscosities of pureed foods, while maintaining the monophasic state throughout the freeze-thaw-reheat cycle.

9.2 Methods

Product preparation was carried out as described in section 8.2.1. Pureed foods were fortified with microcrystalline cellulose (JustFiber® BH200FCC, IFC, Nitro, WV) or soy cotyledon fibre (Fibrim®, Protein Technologies International, St. Louis, MO) at a level of 2 g per 125 mL serving.

9.2.1 Viscosity Analysis

Viscosity analysis was carried out as described in section 7.2, with the exception that certain viscosity and rpm (shear rate) curves were generated with spindle RV6.

9.2.2 Statistical Analysis

Bivariate correlations were carried out to compare the viscosities of pureed foods containing soy fibre and microcrystalline cellulose (SPSS 11.5). Paired t-tests were used to compare timed intervals of the viscosity determinations. All tests were run using SPSS (Version 11.5). Tests were significant is < 0.05.

9.3 Results

9.3.1 Viscosity Behaviour of Pureed Foods

Figure 9.1 provides a graphic representation of apparent viscosity vs rpm (shear rate) for commercial vanilla pudding. **Figure 9.2** shows the plots of apparent viscosity vs rpm (shear rate) for pureed beef, potato, carrot and beef stew systems fortified with 2 g per serving of soy fibre at 55°C. **Figure 9.3** shows the plots of the apparent viscosity vs rpm (shear rate) for pureed beef, potato, carrot and beef stew systems, fortified with 2 g per serving of microcrystalline cellulose at 55°C. The viscosity vs rpm (shear rate) curves for pureed beef, potato, carrot and beef stew systems containing soy fibre were highly correlated with the viscosities vs rpm (shear rate) curves for the same systems containing microcrystalline cellulose [beef: $r = 0.997$ ($p < 0.001$); potato: $r = 0.997$ ($p < 0.001$), carrot: $r = 0.993$ ($p < 0.001$), and beef stew: $r = 0.999$ ($p < 0.001$)]. The viscosity vs rpm (shear rate) curves for beef, potato, carrot and beef stew pureed foods fortified with microcrystalline fibre were significantly correlated with that of commercial vanilla pudding [beef ($r = 0.990$, $p < 0.001$); potato ($r = 0.989$, $p < 0.001$); carrot ($r = 0.899$, $p < 0.001$); beef stew ($r = 0.988$, $p < 0.001$)].

Figure 9.1. Relationship between rpm and viscosity of Jello® prepared vanilla pudding at 4°C, 22° C and 55°C (spindle #5) (n = 2).

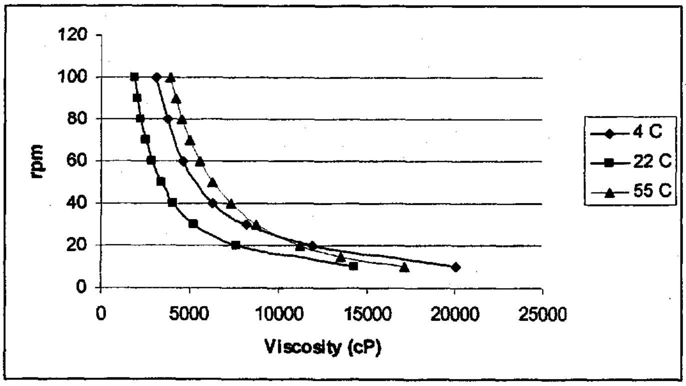
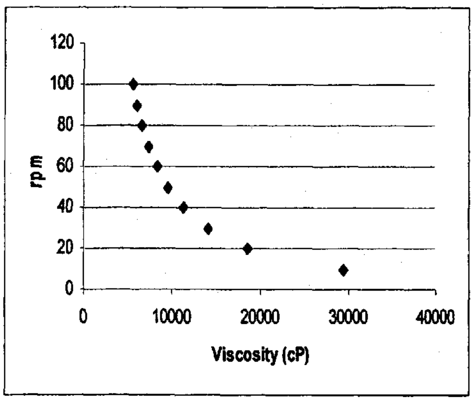
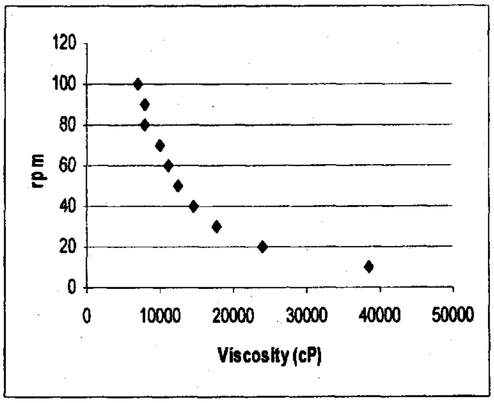


Figure 9.2. Rpm versus viscosity for pureed beef, potato, carrot and beef stew containing 2 g per 125 mL of soy cotyledon fibre at 55°C (n=2).

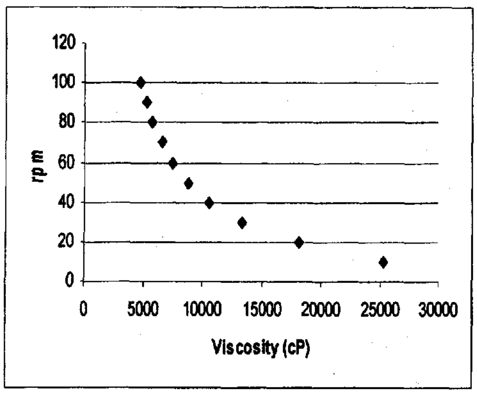
a. Beef



b. Potato



c. Carrot



d. Beef stew

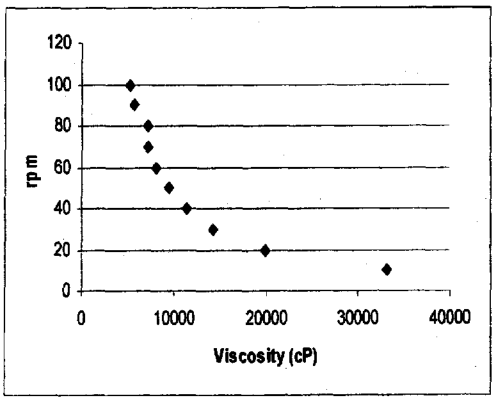
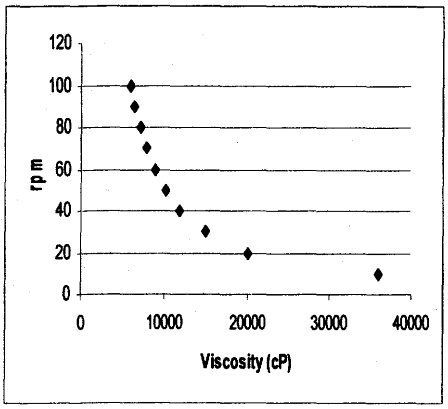
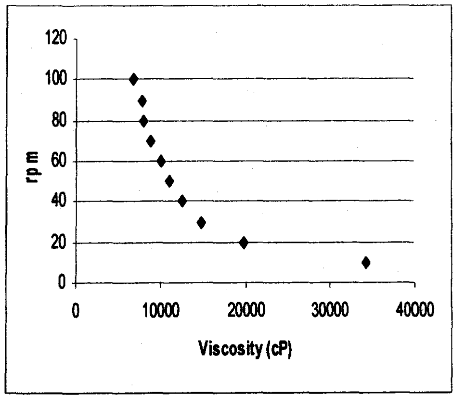


Figure 9.3. Rpm versus viscosity for pureed beef, potato, carrot and beef stew containing 2 g per 125 mL of microcrystalline cellulose at 55°C (n = 2).

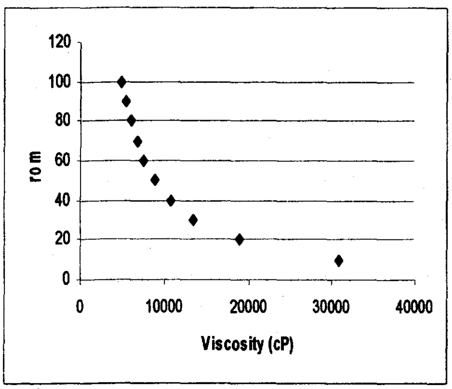
a. Beef



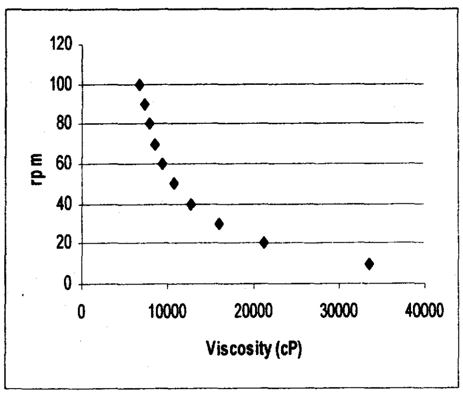
b. Potato



c. Carrot



d. Beef stew



A comparison of viscosity measurements at one and two minutes showed no differences among the beef, carrot, and beef stew systems. However, the viscosity of pureed potato was significantly reduced at two minutes of shearing compared to one minute ($p < 0.05$).

9.3.2 Fibre Fortification with Microcrystalline Cellulose

Table 9.1 describes the impact of increases in microcrystalline cellulose concentration on the viscosities of beef, potato, carrot and beef stew pureed foods. A strong positive correlation ($r = +0.929$; $p < 0.01$) existed between the grams of microcrystalline cellulose per serving and viscosity for pureed systems with the exception of carrot.

Table 9.1. The effect of incremental increases in microcrystalline cellulose concentration on the viscosities of pureed beef, potato, carrot and beef stew pureed foods (48-56 C) (n = 2).

Fibre (g/serving)	Beef	Potato	Carrot	Beef stew
0	ND	22073 ± 1038	26760 ± 1100	20267 ± 716
1	20707 ± 586	22033 ± 887	24396 ± 516	20120 ± 265
2	23133 ± 57	22560 ± 452	25239 ± 1026	24593 ± 617
3	Too viscous	25687 ± 824	26573 ± 19	28557 ± 793
4	Too viscous	Too viscous	39780 ± 632	Too viscous

Too viscous is greater than 50,000 cP

ND Not Determined

9.3.3 Xanthan gum

Tables 9.2 shows the effects of incremental decreases in xanthan gum concentration on the viscosity of pureed carrot, potato, beef and beef stew. Viscosity was significantly correlated with level of xanthan gum.

Table 9.2. The effect of incremental decreases in xanthan concentration on the viscosities of pureed beef, potato, carrot and beef stew pureed foods containing 2 g of microcrystalline cellulose per serving at 54-56°C.

Xanthan (% decrease)	Beef	Potato	Carrot	Beef stew
0	24646 ± 178	24427	25165 ± 776	23633 ± 51
10	22507 ± 159	23031	14836 ± 241	22233 ± 109
20	21427 ± 94	16560	15368 ± 325	21567 ± 189
30	20447 ± 143	16005	14747 ± 189	20425 ± 133
40	18207 ± 334	ND	ND	18967 ± 184

ND Not determined

* Too thin for pudding consistency.

9.3.4 Prediction of the Effect of Pea Hull Fibre

Table 9.3 gives viscosity, consistency and line spread test results of pureed food products containing microcrystalline cellulose/xanthan gum, pea hull fibre/xanthan gum and soy cotyledon/xanthan gum pureed food products. The viscosities of the beef, carrot and potato purees containing pea hull fibre were not significantly different from those containing microcrystalline cellulose. Significantly more xanthan gum was required to achieve the target viscosity in carrot, potato and beef purees containing microcrystalline cellulose and pea hull compared to those purees containing soy cotyledon fibre. This was not the case for beef stew puree.

Table 9.3. Viscosity results for the of microcrystalline/xanthan gum control and pea hull fibre/xanthan gum and soy cotyledon fibre/xanthan gum pureed food products and the ratio of fibre to xanthan gum needed to achieve target viscosities (n=4).

Product and Fibre Source (2g/serving)	Viscosity (cP)	Ratio of fibre (g) to xanthan (g)
Potato/MCC	21640 ± 632	1.0 : 0.20
Potato/pea hull	23280 ± 859	1.0 : 0.20
Potato/soy	24073 ± 338	1.0 : 0.08
Carrot/MCC	24567 ± 150	1.0 : 0.38
Carrot/pea hull	26220 ± 793	1.0 : 0.38
Carrot/soy	24007 ± 224	1.0 : 0.28
Beef /MCC	24646 ± 178	1.0 : 0.20
Beef /pea hull	24010 ± 1056	1.0 : 0.20
Beef/soy	24580 ± 225	1.0 : 0.07
Stew/MCC	23633 ± 51	1.0 : 0.20
Stew /pea hull	24060 ± 504	1.0 : 0.01
Stew /soy	24180 ± 184	1.0 : 0.01

9.4 Discussion

The first objective of this investigation was to describe the viscosity characteristics of pureed foods. The pureed foods studied in this investigation exhibited non-Newtonian viscosity behavior. The apparent viscosity of the pureed foods decreased with increased rpm (shear rate), a phenomenon known as shear thinning. Hence, these foods systems would be classified as pseudoplastic. In addition, the pureed potato model exhibited time thinning and would be classified as thixotropic. The time thinning of the potato system would be due to the disruption of the starch gel network. The pudding standard also exhibited non-Newtonian behaviour with shear thinning, and would, therefore, also be classified as pseudoplastic.

The second objective of this study was to determine the effects of incremental changes in the levels of fibre ingredients on the viscosities of pureed foods. Increases in microcrystalline cellulose were significantly and directly related to viscosity as determined by the Brookfield viscometer in all pureed foods with the exception of carrot.

The addition of microcrystalline cellulose to pureed carrot containing xanthan gum had the least effect on viscosity, likely due to the high level of free water in the carrot system. The addition of microcrystalline cellulose to provide four grams of fibre per serving, potentially labeled as a good source of fibre (Health Canada, 1996), by textural standards could be achieved in the carrot model with no change in xanthan gum concentration. However, as product ingredient costs are a concern in both commercial and institutional food production, a reduction in xanthan gum concentration would be desirable. With carrots, however, small reductions in xanthan gum had significant effects on viscosity and a reduction in xanthan gum concentration could not be recommended if product textural quality is to be maintained.

Pureed potatoes could be prepared to provide a maximum of 3 g/serving of dietary fibre from microcrystalline cellulose while maintaining viscosity near the target pudding viscosity at the commercial level of xanthan gum. Fibre enhancements above 3 g/serving resulted in viscosities significantly higher than the recommended pudding consistency. A reduction of 20-30% in xanthan gum produced an estimated 30-35% reduction in viscosity, thus a reduction in xanthan may function to allow a further increase in insoluble fibre enhancement in the potato system. However, there is seasonal variation in the starch content of root vegetables and tubers. Therefore, quality control methods to ensure appropriate viscosities would be required with each batch of production.

The viscosity of beef and beef stew were also increased with the addition of microcrystalline cellulose. Beyond the addition of 2 g/serving of fibre from microcrystalline cellulose in beef and 3 g/serving of fibre in beef stew, viscosity was too high to be determined with the methodology employed. A 40% reduction in xanthan gum resulted in about a 25% reduction in viscosity. A substantial reduction in xanthan gum may function to allow marginally higher fibre fortification of pureed beef and beef stew.

Adjustments of insoluble fibre and xanthan gum will potentially affect the cohesiveness, adhesiveness and hardness of pureed foods. As demonstrated in Chapter 8 demonstrated, the adhesiveness and hardness of the pea hull fibre pureed foods were similar to the pudding standard. A substantial decrease in xanthan in a given pureed food system may affect not only viscosity but also hardness, adhesiveness and cohesiveness.

The viscosity-enhancing behavior of microcrystalline cellulose could be used to predict the amount of pea hull fibre for recipe development in the puree carrot, potato and beef systems, but less so in the stew system. The required insoluble fibre:xanthan gum ratio for the pea fibre fortified pureed foods system resembled the soy cotyledon fibre:xanthan gum ratio for the stew system.

No correlations were found between the viscosity, line spread and consistometer measurements at the target pudding-like consistency. Thus, consistency as determined with the Bostwick Consistometer or by the line spread test is not appropriate for estimating the viscosity-enhancing properties of an insoluble fibre source in pureed foods, as these tools are not sufficiently sensitive at the relatively viscosity of the pureed foods systems and should not be used for pureed product development or quality control of pureed foods. This finding supports the conclusions of Chapter 7, i.e. that both the Bostwick Consistometer and line spread test are inappropriate for predicting the viscosity of, for the quality control of, pureed foods.

9.5 Conclusion

It can be concluded that varying levels of soluble and insoluble fibre may be used to achieve target viscosities in pureed foods systems. Substantial levels of insoluble fibre can be added to pureed foods while maintaining a pudding-like viscosity. Syneresis was not noted in any pureed food system that was developed. Therefore, many combinations of soluble and insoluble fibre sources provide sufficient water-holding capacity to maintain a monophasic pureed food system that will exhibit pudding-like behavior.

10. GENERAL DISCUSSION

10.1 Fibre Fortification of the Long term Care Diet

The research in this thesis confirms recent findings (Lengyel, 2002), that the provision of fibre to long term care residents in Saskatchewan is inadequate and that the average intake of fibre by individuals residing in long term care homes is, therefore, also inadequate. However, many of the health advantages of consuming fibre are less important for the institutionalized elderly. The average length of stay of long term care residents (most commonly ending in death) in Saskatchewan is less than 4 years (Saskatchewan Health, 2002), hence the effect of an increase in fibre intake on risk reduction for the development of CHD, diverticular disease and colon cancer is of less significance than quality of life.

The physiological benefits of viscous fibre, such as cholesterol lowering, will be unlikely to contribute to increased life expectancy and quality of life of long term care residents. Improved glycemic control of those long term care residents with diabetes, due to increased viscous fibre intakes, may provide an improvement in serum glucose control and may then potentially reduce morbidity and improve quality of life by decreasing diabetes related symptoms. However, the satiety effects of viscous, soluble fibre could be contraindicated for those residents with poor food intake. As delayed gastric emptying is a concern for some elderly, such as those with diabetes-related gastroparesis, viscous fibres that may further delay gastric emptying would be contraindicated. In addition, the side effects of bloating and flatulence, associated with highly fermentable soluble fibre, may contribute to abdominal discomfort and pain and, thus decrease the quality of life of long term care residents. However, the consumption and subsequent fermentation of prebiotic fibre sources, such as inulin or fructo-oligosaccharides, leads to the enhancement of the bifidobacterial population in the colon. This may function to enhance immunity (Swanson, Grieshop, Flickinger, Healy, Dawson, Merchen & Fahey, 2002), and to protect individuals from diarrheal episodes due to pathogenic bacteria (Hoekstra, Szajewska, Zikri, Micetic-Turk, Weizman, Papadopoulou, Guarino, Dias & Oostvogels, 2004).

In contrast, there is significant benefit to insoluble fibre fortification of the diets of long term care residents. First and foremost, increased insoluble fibre will result in fecal bulking, diminished symptoms of constipation and likely a decreased need for laxatives and enemas. In addition, fortification with insoluble fibre may function to decrease the incidence of diverticulitis, however, most long term care residents already have established diverticular disease. Furthermore, insoluble fibre fortification will have little effect on gastric emptying and satiety, and may improve appetite with the alleviation of constipation.

The current fibre recommendations, albeit for the healthy population, are that fibre should be provided in the diet at a level of 14 g/1000 kcal (IOM, 2002). The product of the Estimated Energy Requirement (EER) for active healthy individuals and the g/kcal fibre recommendation gives the fibre recommendation in g/day. The EER of healthy elderly women is 1500 kcal/day, and that of healthy elderly men is 2100 kcal/day, thereby providing adequate fibre intakes of 21 and 30 g/day (IOM, 2002), respectively.

Most institutionized elderly are less active than healthy, free-living elderly and, therefore, have reduced energy needs but need as much or more fibre. Residents of long term care facilities consume, on average, 1000-1500 kcal/day (Wendland et al, 2003). This would equate to 14-21 g/day of fibre. However, actual average fibre intakes are less than 10 g/day (Lengyel, 2002). The recommendation for fibre intake for institutionalized individuals should be set to exceed the current fibre recommendation of 14 g/1,000 kcal as medications, immobility, lack of privacy and disease states further contribute to constipation (Schaeffer & Cheskin, 1998; Wilson, 1999). Instead, a target of 20 g of fibre per 1000 kcal per day, emphasizing insoluble, less fermentable fibre sources, may be needed for most long term care residents if they are to achieve an AI of fibre of 20 to 30 grams per day. Thus, an elderly female with an energy intake of 1200 kcal/day would just exceed the AI of 21 g/day and an elderly man with an energy intake of 1500 kcal/day would meet his requirement of 30 g/day.

The provision of adequate fibre to institutionalized elderly requires the provision of fibre beyond levels that are commonly contained in the usual foods offered in Canadian institutions. An addition of more than 10 g of fibre, primarily insoluble, to the usual institutional meal day is required to meet recommendations at current energy intakes. Meeting the fibre fortification target of 20 g/1000 kcal with a traditional insoluble fibre source such as wheat bran, is unlikely to be successful as more than 25 g (> six tablespoons) of wheat bran would be required. Instead, a concentrated, finely processed insoluble fibre source, such as pea hull fibre offers a feasible solution to fibre fortification of long term care diets.

In the current study, it was possible to increase the total fibre offered to long term care residents by about 4 g/day through in-house fortification, without decreasing the acceptability of the foods offered. The level of dietary fibre offered in the study facility prior to the study was 18.5 g/day, or about 10 g of fibre per 1000 kcal offered, less than the current recommendations for total fibre of 14 g/1000 kcal for healthy individuals (IOM, 2002). As residents of long term care facilities consume only two-thirds of the standard meal day (Lengyel, 2002), it is likely that residents of the facility consumed no more than 11 g/day of fibre and this may be a major reason for the high laxative use in the long term care facility studied. It is often stated in nutrition protocols (ADA 2002), that increased dietary fibre must be accompanied by increased fluids. The current literature does not support this premise (Chung et al, 1999) and the protocol of the current study did not include any intentional increase in fluid offered. The addition of finely processed insoluble fibre without a recommendation for additional fluid had a no detrimental effect on fluid status and no apparent effect on fibre functionality. However, as many long term care residents may suffer from dehydration, consumption of adequate fluid through beverages and foods is recommended.

There was a significant decline in the rate of administration of fruit/prune puree, but the administration of pharmaceutical laxatives and enema administration did not change, during the 6-week fibre fortification study, indicating a lack of assessment of need prior to the administration of enemas and laxatives. The practice of pharmaceutical and food-based laxative administration is not evidence-based and needs to be questioned, particularly the widespread use of pharmaceutical laxatives with limited efficacy. The long term care facility taking part in the study described in Chapter 4 offered fruitlax, a pureed mixture of prunes and other fruits, as a therapy for constipation. Fruitlax is composed of prunes, other pureed dried fruit such as figs, dates and raisins, and may contain fruit juice. Known recipes for fruitlax indicate that it contains less than 40% prune. Therefore, a therapeutic dose of fruitlax would need to exceed the 250 g per day found to be effective (Tinker et al, 1991), if significant stool bulking is to be achieved. As the amount of prune offered in fruitlax in this long term care facility were considerably less, it can be concluded that the current use of fruitlax has little or no efficacy in the treatment or prevention of constipation, and that the 32% of residents administered fruit/prune puree were given a dosage (about 50 g/day) substantially less than that required for a laxative effect.

The administration of pharmaceutical laxatives in the long term care facility studied was not evidence-based. Docusate sodium, although not efficacious in the long term treatment of constipation in the elderly (Castle et al, 1991), was administered to many of the residents. Sennoside products, with their inherent dependency and neurotoxic effects (Harari et al, 1993; Lederle, 1995) and although there are only indicated for the short-term management of constipation they were routinely administered long term. Lactulose, which has the least risk and known effectiveness in the prevention and treatment of constipation in the elderly (Lederle, 1995), was administered to only 12% of the residents. Enema administration to 58% of residents, with its inherent risks and discomfort (Allesa, 1988; Romero et al., 1996), suggests inappropriate use. The long term effect of fibre fortification of long term care diets in combination with nursing education and protocols to reduce enema and laxative administration requires investigation.

The research contained in this thesis supports the fortification of regular and texture-modified foods as a reasonable and efficacious practice to treat and prevent constipation in long term care residents. Further enhancement of long term care diets to increase fortification to 10 g/day of insoluble fibre, as well as ensuring the provision of fibre to those long term care residents that are prescribed texture-modified diets (commonly pureed foods), will function further to alleviate constipation.

10.1.1 Fibre Fortification of the Regular Diet

It was hypothesized that fibre fortification of the regular institutional diet could be achieved by the addition of pea hull fibre to usual foods. Pea hull fibre is high in both total and insoluble fibre and is, therefore, suitable for fortification of long term care diets. As demonstrated in Chapter 4, a moderate addition of pea hull fibre resulted in perceived fecal bulking and increased bowel movement frequency, supporting previous research that pea hull fibre has significant fecal bulking capacity (Stephen, Morgan, Dahl et al, 1992).

Foods served daily in most long term care facilities provide a reliable vehicle for fibre fortification for many residents. To achieve significant insoluble fibre fortification, hot cereals such as oatmeal and Cream of Wheat® should be fortified with 2- 4 g of fibre per 125 mL serving. Baked goods, such as cookies, cakes and muffins, are easily fortified with pea hull fibre by food service staff at a long term care facility. However, if baked goods are offered as snacks, they may not be consumed by all residents. Often there is no provision of snacks to all residents or lack of assistance with eating during snack time, or both, and these may influence whether or not residents benefit from this vehicle of fibre fortification. Observations made during the fibre fortification study suggested that only more functionally mobile, non-dysphagic individuals consumed snacks on a regular basis.

As Chapter 4 outlines, the fortification of hot cereal, baked products and other usual menu items provided an additional 3.6 g of fibre per day, thus the fortified menu offered about 12 g per 1000 kcal, falling short of the proposed fibre fortification recommendation above. The bread was outsourced by the study facility described in Chapter 4 and, therefore, was not included as a food vehicle for fibre fortification. Although whole wheat bread may be served to some residents, the amount of fibre per slice of white bread and white buns is negligible. However, provision of commercial white bread and buns, fortified with pea hull fibre, offers a possible venue to increase the level of fibre fortification. Furthermore, long term care residents, with their low caloric intakes, may consume only 1-2 slices of bread per day, providing 1-3 g of fibre for whole wheat bread and less than a gram of fibre for white bread. Fortification of white bread and further enhancement of the total fibre content of whole grain bread with a concentrated fibre source such as pea hull fibre, may contribute an additional 3-6 g of fibre per day to the long term care diet. As Chapter 5 indicates, white bread fortified with pea hull fibre maintains its loaf volume and freshness. Commercial formulations meeting industrial specifications and standards of acceptability have been achieved with bread using high levels of pea hull fibre, thus providing up to 11 g of total fibre per 40 g of bread (Personal Communication; Kelly Moodry, Dawn Foods Products (Canada), Saskatoon, SK., Limited, January 2003)

10.1.2 Fibre Fortification of Pureed Foods

Fibre fortification of long term care diets must include both regular and texture-modified diets if recommended total fibre levels are to be offered to all long term care residents. As baked products and bread are missing in the pureed diets offered in Saskatchewan, relying on the fortification of these foods to ensure adequate fibre provision for dysphagic individuals would be unsuccessful. The research presented in Chapter 8 supports the premise that the fortification of commonly-offered pureed foods, including pureed meats, potatoes and casserole, is a feasible means of fibre fortification of the institutional pureed diet. Chapter 8 revealed that fortification of pureed beef, potato and beef stew with pea hull fibre resulted in products that were both acceptable in terms of sensory characteristics and functional.

The results presented in Chapter 6 confirmed that baked products and most cereal-based foods are not provided, for the most part, to long term care residents on pureed diets. Thus, these residents would not benefit from fibre fortification of baked products. Baked products, such as those evaluated in Chapter 5, are commonly served in long term care facilities and offer a highly acceptable food vehicle for fibre fortification of 2 g or more per serving for those residents consuming the regular diet.

The findings in Chapter 6 and 7 suggest that it may be common practice in long term care facilities to prepare pureed foods with little attention to quality control, particularly textural control, as viscosity and consistency of institutionally prepared pureed foods deviated from the recommended pudding-like consistency standard. Pea hull fibre offers a solution to watery, thin purees; hence is a fibre ingredient that can function to provide pureed foods of appropriate consistency/viscosity, as well as to enhance fibre. As proposed in Chapter 7, objective measures are needed to ensure appropriate textural characteristics for pureed foods with and without fibre fortification.

Not all fibre sources would be appropriate for fibre fortification of pureed foods. The traditional fibre source, wheat bran has an average particle size of greater than 1 mm, but particle size of this fibre could be reduced. As pureed foods need to be produced to a consistency that precludes mastication, traditional wheat bran is not appropriate. Instead, finely processed fibre sources are required. Both Exlite® and Centara III® pea fibre possess particle sizes of less than 100 μm. However, a sensory characteristic of grittiness, particularly in pureed carrot, was described by some sensory panelists (Chapter 8). Grittiness was not observed in the pureed meat or stew. Further research is required to determine if the modification of particle size of pea hull fibre would serve to eliminate this unpleasant textural characteristic in some pureed foods.

Commercial pureed foods often rely on soluble fibre or modified starch, or both, to ensure both appropriate consistency and water holding capacity. Soluble fibres, particularly gums, function well to increase viscosity and maximize water holding capacity. However, only small amounts of these fibre sources are required to achieve maximum viscosity and water holding ability. Thus, the addition of high viscosity fibre sources, alone, to pureed foods will not contribute an appreciable amount of fibre to the diets of dysphagic individuals. Other fibre sources that have higher soluble fibre contents, such as soy cotyledon fibre, when added to pureed foods will function to increase the fibre content of pureed foods, but may offer limited physiological benefit, specifically fecal bulking and the relief of constipation, to those individuals consuming the pureed foods. Although modified starch may function well to increase viscosity and prevent syneresis, it contributes no dietary fibre or other needed nutrients. In addition, as modified starch is prone to hydrolysis by salivary amylase, the viscosity of high moisture pureed foods thickened with modified starch potentially may decline during eating due to the introduction of saliva (with salivary amylase) from the feeding spoon into the pureed food. This may be more apt to occur with the slower rate of eating/feeding that is common with dysphagic long term care residents, and may pose a risk if viscosity decreases substantially.

As presented in Chapter 8, the substitution of pea hull fibre for soluble soy cotyledon fibre in commercial purees was achieved with an increase in xanthan gum. This was expected, as the water binding capacity of pea hull fibre is less than that of soy cotyledon fibre. Pureed foods prepared with pea hull fibre exhibited excellent freeze-thaw-reheat stability, as no evidence of syneresis was found. This suggests that higher levels of fibre fortification may be possible with an insoluble fibre source such as pea hull fibre, compared to a source of soluble fibre such as soy cotyledon fibre, maintaining similar levels of xanthan gum. Thus, the commercial substitution of pea hull fibre for soy cotyledon fibre could function to maintain or improve the fibre content of commercial pureed foods while maintaining their functional characteristics.

The successful incorporation of pea hull fibre into pureed foods suggests that the incorporation of finely processed insoluble fibre can function to provide a physiologically effective fibre source as well as the textural characteristics required of pureed foods for safe swallowing. In Chapter 9, it was shown that incremental increases in the level of finely processed insoluble fibre, microcrystalline cellulose, described as low viscosity fibre, had significant viscosity enhancing effects on pureed foods. Finely processed, low viscosity fibre ingredients could be interchanged without significant effects on viscosity. The replacement of soy cotyledon fibre with microcrystalline cellulose requires an adjustment of gum if viscosity is to be maintained. However, data suggest that some commercial pureed foods may be too viscous and adhesive, supporting the use of low viscosity fibre ingredients such as pea hull fibre instead of soy cotyledon fibre with little or no increase in the level of xanthan gum. Pureed foods containing a source of fibre (2 g/serving) were achieved. However, pureed food products containing a good source of fibre (4 g/serving) were not achieved, due to unacceptable increases in viscosity if xanthan gum levels were maintained. As it is possible for a variety of pureed food products to be fibre-fortified, fortification above 2-3 g/serving may not be required.

As the current fibre intakes of long term care residents consuming pureed foods were found to be approximately 9.6 g per day (Chapter 6), the consumption of an additional 10 g of fibre per day or so, through fortification, is suggested if dysphagic individuals are to approach recommended intakes of fibre. Fortification of up to five pureed food items at 2 g per serving would be required to achieve adequate fibre intakes. Fibre fortification of hot cereal could provide an additional 2 g of fibre per 125 mL serving. Some dysphagic residents may consume 250 mL of cereal, particularly if cereal is offered as an evening snack, thereby providing a total of 4 g of fibre per day.

Pureed beef fortified with pea hull fibre was highly acceptable at 2 g of fibre per serving and not distinguishable from commercial soy cotyledon-fortified pureed beef. Hence, pureed beef and possibly other meats may provide a vehicle for fibre enhancement. Pureed meat, fortified with pea hull fibre, may offer an additional 2 g/serving of fibre and when offered twice daily would provide an additional 4 g/day of fibre for long term care residents consuming the pureed diet.

The fibre fortification of carrots with pea hull fibre was not acceptable and, therefore, would not be recommended. Commercial pureed carrots are particularly smooth, with no particles in excess of 1 mm^2 and 64% of particles less than 212 μm. Institutionally-prepared pureed carrots were also smooth with fine particle size. It is possible that the smooth texture of pureed carrots, and possibly other pureed vegetables, does not lend itself to incorporation of pea hull fibre. Although 95% of Centara III® pea hull fibre has a particle size of less than 100 μm in the dry state, with a water absorption capacity of 5.7 g/g of fibre, its fibre particles, in hydrated form, would become larger and, therefore, detectable in a smooth vegetable puree.

The fibre fortification of pureed potato poses other issues. Although pureed potatoes fortified with pea hull fibre were rated as acceptable, the appropriateness of potatoes in the pureed diet must be considered. As stated in Chapter 6, pureed potatoes are offered to long term care residents as often as twice a day. However, assessment of the adhesiveness of pureed potatoes, if not prepared with sufficient fat, suggests that pureed potatoes may not be appropriate for all dysphagic individuals. Furthermore, pureed potatoes supplant pureed breads and cereals in the pureed diets offered in Saskatchewan long term care facilities. The omission of cereal-based foods from the pureed diet poses much more serious nutritional risks than the lack of a medium for fibre enhancement. The dearth of cereal-based foods indicates that long term care residents may not be benefiting from the fortification of grain products, and critical nutrients, such as folate, may be lacking. Therefore, although the fortification of potatoes is achievable, acceptable and would function as a reliable food vehicle to improve the fibre intakes of long term care residents consuming pureed foods, research should be carried out to develop acceptable, fibre-containing, grain-based pureed foods, thereby, improving the variety and nutritional quality of pureed diets.

10.2 Quality Standards and Ready-to-Swallow Composition for Pureed Foods

Diets for the management of dysphagia should be highly individualized and altered with changes in the dysphagic individual's ability to swallow. This requires close monitoring with swallowing assessments, which are time consuming, costly and moderately invasive and, therefore, may not be done in an era of limited health care resources.

Although, the importance of the textural qualities of pureed food for dysphagic management has been emphasized (ADA, 2000), no specifications or standards for textural characteristics of pureed foods have been outlined. Viscosity is the key textural characteristic assessed to ensure the appropriateness and safety of thickened beverages (formulated for dysphagic individuals). The research described in Chapter 7 indicates that viscosity may not be the most appropriate tool for quality control in institutional pureed food production. Viscosity may be appropriate for quality control of commercial purees if target viscosities of purees are such that they can be assessed using a viscometer, but many institutionally produced purees were too viscous to be assessed accurately with the Brookfield viscometer. The Brookfield viscometer, using a standard method, as with the Bostwick and line spread test, was unable to assess pureed foods with viscosities much in excess of the pudding-like standard. As the safe, appropriate upper range of viscosities for dysphagic pureed foods has not been outlined, it is not known if pureed foods unable to be accurately assessed by the Brookfield viscometer, Bostwick consistometer and line spread test are too viscous to be safely consumed by dysphagic individuals. Until objective texture guidelines for safe swallowing are outlined, alternative textural characteristics may need to be assessed to describe thicker pureed foods, or other apparatuses that may be able to assess the viscosity of pureed foods could be evaluated. As the findings of Chapter 7 suggest, hardness may be a more appropriate textural characteristic for pureed food for quality control.

The results presented in Chapter 7 suggest that the textural characteristics of pureed foods vary in terms of viscosity, consistency and particle size. The lack of quality control procedures in pureed food production and little awareness of a requirement for consistency of pureed foods confirm these findings (Chapter 6). Although no objective standards for pureed foods have been published, guidelines suggest that pureed foods should be homogeneous, very cohesive, pudding-like, requiring no bolus control and no chewing can be required. The published literature provides evidence related to a 'ready to swallow' food bolus. A minimum food bolus of 7.5 mL or greater is required for optimal initiation of a swallow (ADA, 2000). Masticated foods often achieve particle sizes of less than about 1 mm and foods containing larger particles will initiate mastication (Hoebler et al, 2000; Prinz and

Lucas, 1995; Jiffrey and Molligoda, 1983; Jiffry, 1981). Moisture incorporation during mastication most often results in a food bolus of about 70% water by weight (Mioche et al, 2003; Hoebler et al, 1998; Prinz and Lucas, 1995). Although food particle size and moisture content have been indicated as factors with thresholds for swallowing, current evidence suggests that cohesiveness may be critical to the initiation of the swallow (Prinz and Lucas, 1997).

The goal of pureed food preparation is to produce foods that are 'ready to swallow'. First, the preparation of pureed foods to a target particle size is required to prevent the dysphagic individual from wanting or needing to masticate. Second, the moisture content must be sufficient to preclude the incorporation of saliva. Third, a minimum level of viscosity is required to prevent aspiration, as well as to ensure the delivery of an appropriate bolus size for the initiation of a swallow. Fourth, adequate cohesiveness must be achieved to prevent delayed swallowing and aspiration of particles or separated liquid. And finally, pureed foods may need to conform to a yet to be defined level of adhesiveness, and possibly hardness, to limit delays in swallowing and swallowing fatigue.

As outlined in Chapter 7, a screen test can be used to evaluate the particle size of pureed foods. Moisture content can be determined by drying of a known weight of pureed food. A simple predictor of viscosity, the spoon-thickness test described in Chapter 7, can adequately predict minimum viscosity as well as ensure the delivery of a minimum bolus volume of pureed food to the mouth. Appropriate cohesiveness, adhesiveness and hardness can be assessed by TPA, which could be applied to the quality control of commercial pureed foods once standard values and ranges are developed. However, the development of simple, institutionally-appropriate quality control methods for cohesiveness, adhesiveness and hardness may be needed.

The results presented in Chapters 8 and 9 confirm that finely processed fibre can be used to achieve pureed foods with particle sizes of less that 1 mm. The minimum viscosity required for safe pureed foods can be achieved by the addition of finely-processed insoluble fibre ingredients. The use of finely processed insoluble fibre, in combination with a highly viscous fibre ingredient, can result in cohesive pureed foods that remain as such through the cycle of preparation-freezing-reheating, while maintaining a moisture content in excess of 70%. The impact of various ratios of insoluble fibre and highly viscous fibre ingredients on the adhesiveness of pureed foods requires further investigation.

10.3 Sensory Evaluation of Institutional Foods

Food security is "a condition in which all people at all times can acquire safe, nutritionally adequate and personally acceptable foods that are accessible in a manner that maintains human dignity" (Canadian Dietetic Association, 1991). Thus, long term care residents should be offered foods that they find acceptable and appropriate. Institutionalized elderly may suffer from food insecurity, particularly those with dysphagia. If pureed foods that are offered exhibit water separation and contain large particles, they pose a risk to dysphagic individuals consuming those foods. Pureed foods offered may not be nutritionally adequate for individuals consuming low energy intakes (Dahl et al, 2004).

Preparation of all foods, including fortified foods, for long term care residents must not be undertaken haphazardly. The general acceptability of fortified foods is essential, as any factor that diminishes the acceptability of institutional foods may lead to lower intakes and a worsening of malnutrition. Well-controlled, blinded, sensory studies should be undertaken to evaluate fibre-fortified foods. Fibre fortification of foods must consider effects on flavour and texture. The addition of fibre ingredients has been shown to depress flavour (Nelson, 2001). In the studies described in Chapters 4, 5 and 8, no attempt was made to circumvent this potentially negative effect of fibre enhancement. Further studies should be undertaken to determine if the acceptability of foods can be maintained with the addition of pea hull fibre, and how fibre-fortified foods maybe formulated to enhance flavour. The sensory investigations presented in this thesis have resulted in the development of a tool for the evaluation of descriptive textural characteristics of pureed foods. This tool could be used in pureed food product development and quality assurance programs. Steps should be taken to include dysphagic panelists in sensory evaluation as well as elderly individuals.

10.4 Conclusion

The goal of a nutrition intervention for long term care residents must support enhanced quality of life. de Jong et al (2001) suggest that pleasant and satisfying foods may be important factors for maximizing the quality of life in the elderly. Food intended for elderly long term care residents must be more nutrient dense to compensate for decrease intakes and relatively high nutrient needs. If usual foods, however, are replaced with generic, nutrient-fortified foods, the acceptability of such supplemental foods over time is questioned (de Groot & van Staveren, 2001). Thus, development of fibre-fortified foods that are indistinguishable from their low fibre counterparts will ensure that acceptability will be unaffected.

The fortification of a variety of foods with fibre has the advantage of increasing the variety of foods that a long term care resident may choose while improving fibre intakes, and it allows all long term care residents, independent of dentition and swallowing ability to consume adequate fibre. Sensory and textural acceptability of fibre-fortified foods ensures that food intakes will be maintained and fortification will be successful.

10.5 Impact of Findings and Further Research

An investigation into the feasibility of wide spread, longer duration, fibre implementation studies in long term care facilities should be undertaken. Parameters such as nursing labour costs, and laxative and enema costs, could be evaluated. The feasibility and effectiveness of commercial, out-sourced fibre-fortified foods could be studied, as well as the cost-effectiveness of these strategies. As the result of this thesis research, there are a number of health regions in Saskatchewan and beyond that have begun to fortify their long term care diets with pea hull fibre. However, the extent and outcomes of these interventions is unknown.

Further research is required with respect to the sensory acceptability of fibre-fortified pureed foods. As pureed foods have lost both visual and textural characteristics important to food recognition and acceptability and added fibre reduces flavour, the effects of color and flavour enhancement of fibre-fortified pureed foods on acceptability should be investigated. In addition, observations of pureed food production in long term care facilities that participated in these studies suggest that in-house pureed food production involves the addition of excess water and other liquids to foods from the regular diet and thus, may be unpalatable. Research into standard pureed food formulations is required, as well as research into the development of objective textural targets for pureed foods for successful dysphagia management, particularly upper limits for such textural characteristics as adhesiveness, hardness and cohesiveness.

The development and testing of cereal-based pureed foods is required as dysphagic individuals residing in long term care facilities in Saskatchewan are currently consuming diets containing an insufficient number of servings of breads and cereals.

REFERENCES

Abraham, Z. D., & Mehta, T. (1988). Three-week psyllium-husk supplementation: Effect of plasma cholesterol concentrations, fecal steroid excretion, and carbohydrate absorption in men. American Journal of Clinical Nutrition, 47, 67-74.

Alessi, C. A., & Henderson, C. T. (1988). Constipation and fecal impaction in the long-term care patient. Clinical Geriatric Medicine, 4, 571-588.

Aldoori, W. H., Giovannucci, E. L., Rimm, E. B., Wing, A. L., Trichopoulos, D. V., & Willett, W. C. (1994). A prospective study of diet and the risk of symptomatic diverticular disease in men. American Journal of Clinical Nutrition, 60, 757-764.

Aldoori, W. H., Giovannucci, E. L., Rimm, E. B., Ascherio, A., Stampfer, M. J., Colditz, G. A., Wing, A., Trichopoulus, D. V., & Willett, W. C. (1995). Prospective study of physical activity and the risk of symptomatic diverticular disease in men. Gut., 36, 276-282.

Aldoori, W. H., Giovannucci, E. L., Stampfer, M. J., Rimm, E.B., Wing, A. L., & Willett, W. C. (1997). Prospective study of diet and the risk of duodenal ulcer in men. American Journal of Epidemiology, 145, 42-50.

American Dietetic Association. (2000). Manual of Clinical Dietetics (Chapter 57). Chicago, IL: American Dietetic Association.

American Dietetic Association. (2002). National dysphagia diet: Standardization for optimal care (Section 3). Chicago, IL: American Dietetic Association.

American Dietetic Association. (2002). Position of the American dietetic association: Health implications of dietary fibre. Journal of the American Dietetic Association, 102, 993-994.

Anderson, J. W., & Gustafson, N. J. (1988). Hypocholesterolemic effects of oat and bean products. American Journal of Clinical Nutrition, 81, 749-753.

Anderson, J. W., Allgood, L. D., Turner, J., Oeltgen, P. R., & Daggy, B. P. (1999). Effects of psyllium on glucose and serum lipid responses in men with type 2 diabetes and hypercholesterolemia. American Journal of Clinical Nutrition, 70, 466-473.

Anderson, J. W., Allgood, L. D., Lawrence, A., Altringer, L. A., Jerdack, G. R., Hengehold, D. A., & Morel, J. G. (2000). Cholesterol-lowering effects of psyllium intake adjunctive to diet therapy in men and women with hypercholesterolemia: Meta-analysis of 8 controlled trials. American Journal of Clinical Nutrition, 71, 472-479.

Anti, M., Pignataro, G., Armuzzi, A., Valenti, A., Iascone, E., Marmo, R., Lamazza, A., Prearoli, A. R., Pace, V., Leo, P., Castelli, A., & Gasbarrini, G. (1998). Water supplementation enhances the effect of high-fibre diet on stool frequency and laxative consumption in adult patients with functional constipation. Hepatogastroenterolgy, 45(21), 727-32.

Arnauld, M. J. (2003). Mild dehydration: a risk factor of constipation? EuropeanJournal of Clinical Nutrition, 57(Suppl 2), S88-95.

Arnold, C., Dahl, W., Poirier, E., Torgerson, C., Shavron, R., &Colwell, R. (2003). Prevalence of malnutrition in Saskatoon special care homes. Proceeding of the Nutrition in Health and Disease: From Bench to Bedside and Beyond: Focus on Adult Critical Illness and Functional Foods. Vancouver, BC, April 24-26.

Ashraf, W., Park, F., Lof, J., & Quigley, E. M. (1995). Effects of psyllium therapy on stool characteristics, colon transit and anorectal function in chronic idiopathic constipation. Alimentary Pharmacology & Therapeutics, 9, 639-647.

Baum, H. M., Sanders, R. G., & Straub, G. J. (1951). The occurrence of a diphenylisatin in California prunes. Journal of the American Pharmaceutical Association, 40(7), 348-349.

Behall, K. M., & Howe, J. C. (1996). Resistant starch as energy. Journal of the American College of Nutrition, 15, 248-254.

Bianchi, M. & Capurso, L. (2002). Effects of guar gum, ispaghula and microcrystalline cellulose on abdominal symptoms, gastric emptying, orocaecal transit time and gas production in healthy volunteers. Digestive Liver Diseases, 34, S129-33.

Birkett, A. M., Jones, G. P., de Silva, A. M., Young, G.P., & Muir, J. G. (1997). Dietary intake and faecal excretion of carbohydrate by Australians: Importance of achieving stool weights greater than 150 g to improve faecal markers relevant to colon cancer risk. European Journal of Clinical Nutrition, 51, 625-632.

Blundell, J. E., & Burley, V. J. (1987). Satiation, satiety and the action of fibre on food intake. International Journal of Obesity, 11, 9-25.

Bolin, T. D., & Santon, R. A. (1998). Flatus emission patterns and fibre intake. European Journal of Surgery, 582, 115-118.

Bonithon-Kopp, C., Kronborg, O., Giacosa, A., Räth, U. & Faive, J. (2000). Calcium and fibre supplementation in prevention of colorectal adenoma recurrence: A randomized intervention trial. Lancet, 356, 1300-1306.

Borne, M. (1982). Food texture and viscosity. New York, NY: Academic Press.

Borne, M. (2002). Food texture and viscosity. New York, NY: Academic Press.

Bouhnik, Y., Flourié, B., Riottot, M., Bisetti, N., Gailing, M.F., Guibert, A., Bornet, F. & Rambaud, J.C. Effects of fructo-oligosaccharides ingestion on fecal bifidobacteria and selected metabolic indexes of colon carcinogenetics. Nutrition and Cancer. 1996; 26:21-29.

Bouhnik, Y., Vahedi, K., Achour, L., Attar, A., Salfati, J., Pochart, P., Marteau, P., Flourié, B., Bournet, F., & Fambaud, J. C. (1999). Short-chain fructo-oligosaccaride administration dose-dependently increases fecal bifidobacteria in healthy humans. Journal of Nutrition, 129, 113-116.

Bourquin, L. D., Titgemeyer, C., Fahey, G. C. Jr., & Garleb, K. A. (1993). Fermentation of dietary fiber by human colonic bacteria: Disappearance of, short-chain fatty acid production from, and potential water-holding capacity of, various substrates. Scandinavian Journal of Gastroenterology, 28, 249-255.

Braaten, J. T., Wood, P. J., Scott, F. W., Wolynetz, M. S., Lowe, M. K., Bradley-White, P., & Collins, M.W. (1994). Oat beta-glucan reduces blood cholesterol concentration in hypercholesterolemic subjects. European Journal of Clinical Nutrition, 48, 465-474.

Briet, F., Achour, L., Flourie, B., Beaugerie, L., Pellier, P., Franshisseur, C., Bornet, F. & Rambaud, J.C. (1995). Symptomatic response to varying levels of fructo-oligosaccharides consumed occasionally or regularly. European Journal of Clinical Nutrition, 49, 501-507.

Brighenti, F., Casiraghi, M.C., Canzi, E. & Ferrari, A. (1999) Effect of consumption of a ready-to-eat breakfast cereal containing inulin on the intestinal milieu and blood lipids in healthy male volunteers. European Journal of Clinical Nutrition, 53, 726-733.

Brodribb, A.J.M. (1977). Treatment of symptomatic diverticular disease with a high-fibre diet. Lancet, 1, 664-666.

Brookfield Engineering Inc. More solutions to sticky problems. Accessed: June, 2003. http://belgmbh.com/download/files/more_solutions.pdf.

Brown, I.L., Rosner, B., Willett, W. & Sacks, F.M. (1999). Cholesterol-lowering effects of dietary fibre: A meta-analysis. American Journal of Clinical Nutrition, 69, 30-42.

Brudevold, F., Kashket, S. & Kent, RL. Jr. (1990). The effect of sucrose and fat in cookies on salivation and oral retention in humans. Journal of Dental Research, 69, 1278-82.

Brune, M., Rossander-Hulten, L., Hallberg, L., Gleerup, A. & Sandberg, A.S. (1992). Iron absorption from bread in humans: Inhibiting effects of cereal fibre, phytate and inositol phosphates with different numbers of phosphate groups. Journal of Nutrition, 122, 442-449.

Buddington, R.K., Williams, C.H., Chen, S.C. & Witherly, S.A. (1996). Dietary supplementation of neosugar alters the fecal flora and decreases activities of some reductive enzymes in human subjects. American Journal of Clinical Nutrition, 63, 709-716.

Burton, R. & Mannin, V. (1982). Influence of psyllium-based fibre preparation on faecal and serum parameters. Acta Medica Scandinavica Supplementum, 668, 91-94.

Castle, S.C., Beverly, L. & Travis, I. (1992). Constipation: Proposed natural Laxative mixtures. Journal of Gerontological Nursing, 10, 5-12.

Castle, S.C., Cantrell, M., Isreal, D.S. & Samuelson, M.J. (1991). Constipation prevention: empiric uses of stool softeners questioned. Geriatrics, 46, 84-6.

Canadian Dietetic Association. (1991). Hunger and food security in Canada: Official position of the Canadian Dietetic Association. Journal of the Canadian Dietetic Association, 53, 139.

Cerda, J.J., Robbins, F.L., Birgin, C.W., Baumgartner, T.G. & Rice, R.W. (1988). The effects of grapefruit pectin on patients at risk for coronary heart disease without altering diet or lifestyle. Clinical Cardiology. 1988; 11:589-594.

Chung, B.D., Parekh, U. & Sellin, J.H. (1999). Effect of increased fluid intake on stool output in normal healthy volunteers. Journal of Clinical Gastroenterology. 1999, 28, 29-32.

Clark, A.N.G. & Scott, J.F. (1976). Wheat bran in dyschezia in the aged. Age Aging, 5, 149.

Cluskey, M.M. (1989). The use of pureed diets among the elderly. Diet Currents, 16, 4.

Cluskey, M.M. (1989). The use of texture modified diets among the institutionalized elderly. Journal of Nutrition of the Elderly, 9, 3-17.

Cottrell, I.W. & Kang, K.S. (1978). Xanthan gum, a unique bacterial polysaccharide for food applications. Developmental Microbiology, 19, 117.

Cormier, D., Harper, D.W., O'Hara, P.A., Brillant, C., Caissie, D., Dubeau, J. & Mitalas, J. (1994). Pureed Diet: prevalence and reported reasons for use in a long term care hospital. Journal of the Canadian Dietetic Association, 55, 121-124.

Cummings, J.H. (1981a). Dietary fiber. British Medical Bulletin, 37, 65-70.

Cummings, J.H. (1981b). Dietary fibre and large bowel cancer. The Proceedings of the Nutrition Society, 40, 7-14.

Cummings, J.H. (1984). Constipation, dietary fiber and the control of large bowel function. Postgradraduate Medicine Journal, 60, 811-819.

Cummings, J.H. (1993). The effect of dietary fibre on fecal weight and composition. In: Spiller GA, ed. CRC Handbook of Dietary Fibre in Human Nutrition, 2nd ed. Boca Raton, FL: CRC Press.

Cummings, J.H. & Bingham, S.A. (1987). Dietary fibre, fermentation and large bowel cancer. Cancer Surveys, 6, 601-21.

Cummings, J.H., Beatty, E.R., Kingman, S.M., Bingham, S.A. & Englyst, H.N. (1996). Digestion and physiological properties of resistant starch in the human large bowel. British Journal of Nutrition, 75, 733-747.

Curran, J. & Groher, M.E. (1990). Development and dissemination of an aspiration risk reduction diet. Dysphagia, 5, 6-12.

Dahl, W.J. (2004). Texture-Modified Food Production: A Manual for Long Term Care Facilities. Dietitians of Canada, Toronto, ON.

Dahl, W.J., Furkalo, R., Kish-Geer, A. & McGladdery, C. (2001). Addition of pea hull fibre to pureed foods for use with dysphagic elderly. Canadian Journal of Dietetic Practice and Research, 62, 150.

Dahl, W.J. & Wasko-Lacey, L. (1999). Laxative use and dietary fiber offered in long term care facilities in rural Saskatchewan. Canadian Journal of Dietetic Practice and Research, 60, 182.

Dahl, W.J., Whiting, S.J. & Stephen, A.M. (1995). Dietary lentils and calcium balance in adult men. Nutrition Research, 15, 1587-1598.

Dahl, W.J., Whiting, S.J., Healey, A.D., Zello, G.A. & Hildebrandt, S.L. (2003). Increased stool frequency and fecal output occurs when finely processed pea hull fiber is added to usual foods consumed by elderly long term care residents. Journal of the American Dietetic Association, 103, 1199-1202.

Dahl, W.J., Whiting, S.J. & Isaac, T.M. (2004). Application of the DRI Planning Process to a Long Term Care Population Offered Pureed Foods. Proceedings of the Canadian Federation of Biological Sciences, June 17-19, 2004, Vancouver, BC.

Dahl, W.J., Whiting, S.J., Zello, G.A. & Stanger, J.D. (2001). The effect of finely processed fibre fortification and cooking time on the quality of cooked pudding. Journal of the American Dietetic Association, 101, A59.

Dahl, W.J. & Zello, G.A. (2001). A survey of clinical dietetic services and therapeutic diets provided to long term care residents in rural Saskatchewan. Health Research and Remote Canada Proceedings. 2001, 2, 15.

Dantas, R.O. & Dobbs, W.J. (1990). Effect of bolus volume and consistency on swallow-induced submental and infrahyriod electromyographic activity. Brazilian Journal of Medical and Biological Research, 23, 37-44.

Davidson, M.H. & Maki, K.C. (1999). Effects of dietary inulin on serum lipids. Journal of Nutrition, 129, 1474S-1477S.

Davidson, M.H., Dugan, L.D., Burns, H., Bova, J., Story, K. & Drennan, K.B. (1991). The hypercholesterolemic effects of β-glucan in oatmeal and oat bran. A dose-controlled study. Journal of the American Medical Association, 265, 1833-1839.

Davidson, M.H., Maki, K.C., Kong, J.C., Dugan, L.D., Torri, S.A., Hall, H.A., Drennan, K.B., Anderson, S.M., Fulgoni, V.L., Saldanda, L.G. & Olson, B.H. (1998). Long term effects of consuming foods containing psyllium seed husk on serum lipids in subjects with hypercholesterolemia. American Journal of Clinical Nutrition, 67, 367-376.

de Groot, L. & van Staveren, W.A. (2001). Appraisal of 4 months' consumption of nutrient-dense foods within the daily feeding pattern of frail elderly. Journal of Aging and Health, 13, 200-213.

de Jong, N., Chin, A., Paw, M.J.M., de Graaf, C., Hiddink, G.J., de Groot, L. & van Staveren, W.A. (2001). Appraisal of 4 months' consumption of nutrient-dense foods within the daily feeding pattern of frail elderly. Journal of Aging and Health, 13, 200-213.

de Jong, N., de Graaf, C. & van Staveren, W.A. (1996). Effect of sucrose in breakfast ítems on pleasantness and food intake in the elderly. Physiology and Behavior, 60, 1453-1462.

Demirag, K., Elmaci, Y, & Altug, T. (1999). Formulation and quality evaluation of reduced sugar and reduced calorie kazandibi. Journal of Food Quality. 1999, 22, 101-108.

Department of Health. (1995). Nutrition guidelines for hospital catering. In Health of the Nation. Department of Health: Wetherby, UK.

DiPalma, J.A. & Brady, C.E. 3rd. (1987). Steakhouse spasm. Journal of Clinical Gastroenterology, 9, 274-8.

Dimmock, E.M. (1937). The prevention of constipation. British Medical Journal, 1, 906.

Dooley, C.P., Scholossmacher, B. & Valenzuela, J.E. (1988). Effects of alterations in bolus viscosity on esophageal peristalsis in humans. American Journal of Physiology, 254, G8-G11.

Downey, G. (2002). Quality changes in frozen and thawed, cooked pureed vegetables containing hydrocolloids, gums and dairy powders. International Journal of Food Science Technology, 37, 869-877.

Drake, C.L., Moses, E.S. & Tandberg, D. (1991). Systematic anaphylaxis after ingestion of a psyllium-containing breakfast cereal. The American Journal of Emergency Medicine, 9, 449-451.

Drewnowski, A., Hendersen, S.A., Driscoll, A. & Ross, B.J. (1996). Salt taste perceptions and preferences are unrelated to sodium consumption in healthy older adults. Journal of the American Dietetic Association, 96, 471-474.

Dror, Y., Stern, F., Nemesh, L., Hart, J. & Grinblat, J. (1996). Macronutrient consumption and nutritional status in a selected well-established group of elderly people in a home for the aged in Israel. Journal of the American College of Nutrition, 15, 475-80.

Dukas, L., Willett, W.C., Giovannucci, E.L. (2003). Association between physical activity, fiber intake, and other lifestyle variables and constipation in a study of women. American Journal of Gastroenterology, 98, 1790-6.

Durrington, P.N., Manning, A.P., Bolton, C.H. & Hartog, M. (1976). Effect of pectin on serum lipids and lipoproteins, whole-gut transit-time, and stool weight. Lancet, 2, 394-396.

Ergun, G.A., Kahrilas, P.J. & Logemann, J.A. (1993). Interpretation of pharyngeal manometric recordings: limitations and variability. Diseases of the Esophagus, 6, 11-16.

Effros, R.M., Hogan, G., Wahlen-Hoagland, K., Olson, L. & Lin,W. (2001). Protection of the lungs from acid during aspiration. American Journal of Medicine, 11 (Suppl 8A), 56S-59S.

Englyst, H.N. and Cummings, J.H. (1984). Simplified method for the measurement of total non-starch polysaccharides by gas-liquid chromatography of constituent sugars as alditol acetates. Analyst, 109, 937-942.

Fineberg, M.J., Knebl, J., Tully, J. & Segall, L. (1990). Aspiration and the elderly. Dysphagia, 5, 61-71.

Finestone, H.M., Fisher, J., Greene-Finestone, L.S., Teasell, R.W. & Craig, I.D. (1998). Sudden death in the dysphagic stroke patient--a case of airway obstruction caused by a food bolus: a brief report. American Journal of Physical Medicine and Rehabilitation, 77, 550-2.

Finiels, H., Strubel, D. & Jacquot, J.M. (2001). Les troubles de la deglutition du sujet age. Aspects epidemiologiques. [Deglutition disorders in the elderly. Epidemiological aspects] La Presse Médicale, 30, 1623-34.

Finlay, M. (1988). The use of dietary fiber in a long-stay geriatric ward. Journal of Nutrition for the Elderly, 8, 19-30.

Finlay, J.M., Smith, A.N., Mitchell, W.D., Anderson, A.J.B. & Eastwood, M.A. (1974). Effects of unprocessed bran on colonic function in normal subjects and in diverticular disease. Lancet, 1, 146-149.

Fraser, G.E., Sabaté, J., Beeson, W.L. & Strahan, T.M. (1992). A possible protective effect of nut consumption on risk of coronary heart disease. The Adventist Health Study. Archives of Internal Medicine, 152, 1416-1424.

Gibson, C.J., Opalka, P.C., Moore, C.A., Brady, R.S. & Mion, L.C. (1995). Effectiveness of bran supplement on the bowel management of elderly rehabilitation patient. Journal of Gerontology Nursing, 21, 21-30.

Glia, A. & Lindberg, G. (1997). Quality of life in patients with different types of functional constipation. Scandinavian Journal of Gastroenterology, 32, 1083-89.

Guedon, C., Ducrotte, P., Antoine, J.M., Denis, P., Colin, R. & Lerebours, E. (1996). Does chronic supplementation of the diet with dietary fibre extracted from pea or carrot affect colonic motility in man? British Journal of Nutrition, 76, 51-61.

Hankey, C.R., Cullen, A., Wynne, H., Death, J. & Kenny, R.A. (1993). Non-starch polysaccaride/dietary fiber supplementation using small meals in long-stay frail elderly patients. European Journal Clinical Nutrition, 47, 521-523.

Harari, D., Gruwitz, J.H. & Minaker, K.L. (1993). Constipation in the elderly. Journal of the American Geriatric Society, 41, 1130-40.

Hassan, F.A.M., Helmy, W.A. & Enab, A.K. (1999). Utilization of some local polysaccharide in manufacturing of yogurt. Egyptian Journal of Dairy Science, 27, 281-289.

Health Canada. (2002). Canada's Aging Population. Division of Aging and Seniors. Catalogue no. H39-608/2002E. Ottawa, ON: Minister of Public Works and Government Services.

Health Canada. (1996). Guide to Food Labelling and Advertising. Section 6.2.4.6.9 Information on Fiber Sources, Section VI: Nutrient Content Claims, Canadian Food Inspection Agency. Ottawa, ON: Health Canada.

Health Canada. (1990). Canada's Food Guide to Healthy Eating. Ottawa, ON: Health Canada.

Health Canada. (1989). Nutrient Value of Common Foods. Ottawa, ON: Health Canada.

Heaton, K.W. (1973). Food fibre as an obstacle to energy intake. Lancet, 64, 312-318.

Heijneen, M.L.A., Van Amelsvoort, J.M.M., Deurenberg, P. & Beynen, A.C. (1998). Limited effect of consumption of uncooked (RS_2) or retrograded (RS_3) resistant starch on putative risk factors for colon cancer in healthy human men. American Journal of Clinical Nutrition, 67, 322-331.

Hoebler, C., Deveux, M.F., Karinthi, A., Belleville, C. & Barry, J.L. (2000). Particle size of solid food after human mastication and in vitro simulation of oral breakdown. International Journal of Food Science and Nutrition, 51, 353-66.

Hoebler, C., Karinthi, A., Deveux, M.F., Guillon, F., Gallant, D.J., Bouchet, B., Melegari, C. & Barry, J.L. (1998). Physical and chemical transformations of cereal food during oral digestion in human subjects. The British Journal of Nutrition. 80, 429-36.

Hoekstra, J.H., Szajewska, H., Zikri, M.A., Micetic-Turk, D., Weizman, Z., Papadopoulou, A., Guarino, A., Dias, J.A. & Oostvogels, B. (2004). Oral rehydration solution containing a mixture of non-digestible carbohydrates in the treatment of acute diarrhea: a multicenter randomized placebo controlled study on behalf of the ESPGHAN working group on intestinal infections. Journal of Pediatric Gastroenterology and Nutrition, 39, 239-45.

Hope, A.K. & Down, E.C. (1986). Dietary fiber and fluid in the control of constipation in a nursing home population. Medical Journal of Australia, 144, 306.

Hotaling, D.L. (1992). Nutritional considerations for the pureed diet texture in dysphagic elderly. Dysphagia, 7, 81-85.

Huffman, G.B. (2002). Evaluating and treating unintentional weight loss in the elderly. American Family Physician, 65, 640-50.

Hull, C., Greco, R.S. & Brooks, D.L. (1980). Alleviation of constipation in the elderly by dietary fiber supplementation. Journal of the American Geriatric Society, 23, 410-414.

Hylla, S., Gostner, A., Dusel, G., Anger, H., Bartman, H.P., Christl, S.U., Kasper, H. & Scheppach, W. (1998). Effects of resistant starch on the colon in healthy volunteers: Possible implications for cancer prevention. American Journal of Clinical Nutrition, 67, 136-142.

Imai, E., Hatae, K. & Shimada, A. (1995). Oral perception of grittiness: Effects of particle size and concentration of the dispersed particles and the dispersion medium. Journal of Textural Studies, 26, 561-576.

Igloe, R.S. (1982). Hydrocolloid interactions useful in food systems. Food Technology, 36, 72-74.

Institute of Medicine (IOM). (2002). Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids. The National Academies Press: Washington, DC.

Jacobs, D.R., Meyer, K.A., Kushi, L.H. & Folsom, A.R. (1998). Whole-grain intake may reduce the risk of ischemic heart disease death in postmenopausal women: The Iowa Women's Health Study. American Journal of Clinical Nutrition, 68, 248-257.

Jenkins, D.J., Jenkins, A.L., Wolever, T.M., Vuksan, V., Rao, A.V., Thompson, L.U. & Josse, R.G. (1994). Low glycemic index: lente carbohydrates and physiological effects of altered food frequency. American Journal of Clinical Nutrition, 59, 706S-709S.

James, J.M., Cook, S.K., Barnett, A. & Sampson, H.A. (1991). Anaphylactic reactions to a psyllium-containing cereal. Journal of Allergy and Clinical Immunology, 88, 402-408.

Jenkins, D.J.A., Kendall, C.W.C., Vuksan, V., Augustin, L.S.A., Li, Y., Lee, B., Mehling, C., Parker, T., Faulkner, D., Seyler, H., Vidgen, E. & Fulgoni, I.I.I. V. (1999). The effect of wheat bran particle size on laxation and colonic fermentation. Journal of the American College of Nutrition, 18, 339-345.

Jenkins, D.J.A., Newton, C., Leeds, A.R. & Cummings, J.H. (1975). Effect of pectin, guar gum, and wheat fibre on serum cholesterol. Lancet, 1, 1116-1117.

Jenkins, D.J.A., Wolever, T.M.S., Leeds, A.R., Gassull, M.A., Haisman, P., Dilawari, J., Goff, D.V., Metz, G.L. & Albert, K.G.M.M. (1978). Dietary fibres, fibre analogues, and glucose tolerance: Importance of v iscosity. British Medical Journal, 1, 1392-1394.

Jiffy, M,T. (1983). Variations in the particles produced at the end of mastication in subjects with different types of dentition. Journal of Oral Rehabilitation, 10, 357-62.

Jiffy, M.T. & Molligoda, A. (1983). Development of the swallowable composition of food in normal dentate subjects. Journal of Oral Rehabilitation, 10, 415-20.

Jiffy, M.T. (1981). Analysis of particles produced at the end of mastication in subjects with normal dentition. Journal of Oral Rehabilitation, 8, 113-9.

Johnson, E.J., Roth, C.A., Reinhardt, J.T. & Marlett, J.A. (1988). Dietary fiber intakes of nursing home residents and independent-living older adults. American Society for Clinical Nutrition, 48, 159-164.

Keller, H.H. (1993). Malnutrition in institutionalized elderly: how and why. Journal of the American Geriatric Society, 41, 1212-1218.

Kim, C.H., Hsu, J.J., O'Conner, M.K., Weaver, A.L., Brown, M.L. & Zinmeister, A.R. (1994). Effect of viscosity on oropharyngeal and esophageal emptying in man. Digestive Disease Science, 39, 189-192.

Klauser, A.G., Beck, A., Schindlbeck, N.E. & Muller-Lissner, S.A. (1990). Low fluid intake lowers stool output in healthy male volunteers. Zeitschrift fur Gastroenterologie, 28, 606-9.

Kleessen, B., Sykura, B., Zunft, H.J. & Blaut, M. (1997). Effects of inulin and lactose on fecal microflora, microbial activity, and bowel habit in elderly constipated persons. American Journal of Clinical Nutrition, 65, 1397-1402.

Kochen, M.M., Wegscheider, K. & Abholtz, H. (1985). Prophylaxis of constipation by wheat bran: A randomized study in hospitalized patients. Digestion, 31, 220-224.

Kruse, H.P., Kleessen, B., Blaut, M. (1999). Effects of inulin on faecal bifidobacteria in human subjects. British Journal of Nutrition, 82, 375-82.

Kumlien, S. & Axelsson, K. (2002). Stroke patients in nursing homes: eating, feeding, nutrition and related care. Journal of Clinical Nursing, 11, 498-509.

Langmore, SE. (1991). Managing the complications of aspiration in dysphagic adults. Seminars in Speech and Language, 12, 199-207.

Langmore, S.E., Terpenning, M.S., Schork, M.S., Chen, Y., Murray, J.T., Lopatin, D. & Loesche, W.J. (1998). Predictors of aspiration pneumonia: how important is dysphagia. Dysphagia, 13, 69-81.

Langmore, S.E., Skarupski, K.A., Park, P.S., Fries B.E.& Brant, E. (2002). Predictors of aspiration pneumonia in nursing home residents. Dysphagia, 17, 298-307.

Lanza, E. (1990). National Cancer Institute Satellite Sumposium of Fiber and Colon Cancer. In: Kirtchevsky, D., Bonfield, C., Anderson, J.W., ed. Dietary Fibre: Chemistry, Physiology, and Health Effects. Plenum Press: New York, NY.

Latner, R.R., Espiritu, B.R., Zumerick, P. & Tobin, M.C. (1990). Anaphylaxis following the ingestion of a psyllium-containing cereal. Journal of the American Medical Association, 264, 2534-2536

Laurin. D., Brodeur, J.M., Bourdages, J., Vallee, R. & Lachapelle, D. (1994). Fibre intake in elderly individuals with poor masticatory performance. Journal Canadian Dental Association, 60, 443-6, 449.

Lazarus, C.L., Logemann, J.A., Rademaker, A.W., Kahrilas, P.J., Pajak, T., Lazar, R. & Halper, A. (1993). Effect of bolus volume, viscosity, and repeated swallows in nonstroke subjects and stroke patients. Archives of Physical Medicine and Rehabilitation, 74, 1066-1070.

Lederle, F.A. (1995). Epidemiology of constipation in elderly patients: Drug utilization and cost-containment strategies. Drugs Aging, 6, 465-469.

Lee, M.F. & Krasinski, S.D. (1998). Human adult-onset lactase decline: an update. Nutrition Reviews, 56(1 Pt 1), 1-8.

Lengyel, C.O., Zello, G.A. & Whiting, S.J. (2003). Evaluation of Menu and Food Service Practices of Long term Care Facilities. Journal of Nutrition in the Elderly, 22, 29-42.

Lengyel, C.O. (2002). Assessment of Food Service Delivery to Elderly Residents in Long term Care Facilities. Ph.D. Thesis, University of Saskatchewan.

Librenti, M.C., Cocchi, M., Orsi, E., Pozza, G. & Micossi, P. (1992). Effect of soya and cellulose fibers on postprandial glycemic response in type II diabetic patients. Diabetes Care, 15, 111-113.

Liedberg, B. & Owall, B. (1991). Masticatory ability in experimentally induced xerostomia. Dysphagia, 6, 211-3.

Lindsay, C. (1999). A portrait of seniors in Canada (3rd Edition). 1999. Catalogue no. 89-519-XPE. Statistics Canada: Ottawa, ON.

Livesay, G. (1990). Energy values of unavailable carbohydrate and diets: An inquiry and analysis. American Journal of Clinical Nutrition, 51, 617-637.

Lo, G.S. (1989). Nutritional and physical properties of dietary fibre from soybeans. Cereal Foods World, 34, 532-534.

Logemann, J.A. (1988). Swallowing physiology and pathophysiology. Otolaryngologic Clinics of North America, 21, 613-23.

Logemann, J.A., Smith, S.H., Pauloski, B.R., Rademaker, A.W., Lazarus, C.L., Colangelo, L.A., Mittal, B., MacCraken, E., Gaziano, J., Stachowiak, L. & Newman, L.A. (2001). Effects of xerostomia on perception and performance of swallow function. Head and Neck, 23, 317-21.

Loughlin, G.M. (1989). Respiratory consequences of dysfunctional swallowing and aspiration. Dysphagia, 3, 126-130.

Low, A.G. (1990). Nutritional regulation of gastric secretion, digestion and emptying. Nutrition Research Reviews, 3, 229-252.

Luo, J., Riskalla, S.W., Alamowitch, C., Boussairi, A., Blayo, A., Barry, J.L., Lafitte, A., Guyon, F., Bournet, F.R.J. & Slama, G. (1996). Chronic consumption of short-chain fructooligosaccarides by healthy subjects decreased basal hepatic glucose production but had not effect on insulin-stimulated glucose metabolism. American Journal of Clinical Nutrition, 63, 939-945.

Lupton, J.R. (1995). Butyrate and colonic cytokinetics: Differences between in vitro and in vivo studies. European Journal of Cancer Prevention, 4, 373-378.

MacMahon, M. & Carless, J. (1998). Ispaghula husk in the treatment of hypercholesterolemia: A double-blind controlled study. Journal of Cardiovascular Risk, 5, 167-172.

Manitoba Health. (2000). Manitoba Centre for Health Policy Evaluation Report. September, 2000.

Mann, L.L. & Wong, K. (1996). Development of an objective method for assessing viscosity of formulated foods and beverages for the dysphagic diet. Journal of the American Dietetic Association, 96(6):585-588.

Mälkki, Y., Heiniö, R.L. & Autio, K. (1993). Influence of oat gum, guar gum and carboxymethyl cellulose on the perception of sweetness and flavour. Food Hydrocolloids, 6, 525-532.

Martin, A.W. (1991). Dietary management of swallowing disorders. Dysphagia, 6, 129-134.

Martin, J. & Blackhouse, J. (1993). Texture modification. In Goodlooking, Easy Swallowing Creative Catering for Modified Texture Diets. Unley, Australia: JFC Foundation.

Martinou-Voulasiki, I.S. & Zerfiridis, G.K. (1990). Effect of some stabilizers on textural and sensory characteristics of yogurt ice cream from sheep's milk. Journal of Food Science, 55, 703-707.

Mayes, C. (1995). Pureed diets 'come alive' with the right food processor. Journal of the American Health Association, 11, 24-8.

McCargar, L.J., Hotson, B.L. & Nozza, A. (1995). Fiber and nutrient intakes of chronic care elderly patients. Journal of Nutrition for the Elderly, 15, 13-30.

McCleary, B.V. & Proskey, L. eds. (2001). Advanced Dietary Fibre Technology 2. Malden, MA: Blackwell Science Ltd..

McCormick, R.D. (1985). Fiber concerns stimulate applications for cellulose and its derivatives. Prepared Foods, 54, 105-106

McRorie, J.W., Daggy, B.P., Morel, J.G., Diersing, P.S., Miner, P.B. & Robinson, M. (1998). Psyllium is superior to docusate sodium for treatment of chronic constipation. Alimentary Pharmacology Therapeutics, 12, 491-7.

McRorie, J., Kesler, J., Bishop, L., Fillon, T., Allgood, G., Sutton, M., Hunt, T., Laurent, A. & Rudolph, C. (2000). Effects of wheat bran and Olestra on objective measures of stool and subjective reports of GI symptoms. American Journal of Gastroenterology, 95, 1244-1252.

Mioche, L., Bourdiol, P. & Monier, S. (2003). Chewing behavior and bolus formation during mastication of meat with different textures. Archives of Oral Biology, 48, 193-200.

Morris, J.N., Marr, J.W. & Clayton, D.G. (1977). Diet and heart: A postscript. British Medical Journal, 2, 1307-1314.

Nelson, A.L. (2001). High-Fibre Ingredients: Practical Guides for the Food Industry. St. Paul, MN: Eagan Press.

Nielsen, B.J. (1984). Combined emulsifier/stabilizers for ice cream. Ice Cream Frozen Confectionary, 35, 401.

Niemi, M.K., Keimänen-Kiukaanniemi, S.M. & Salmela, P.I. (1988). Long term effects of guar gum and microcrystalline cellulose on glycaemic control and serum lipids in type 2 diabetes. European Journal of Clinical Pharmacology, 34, 427-429.

Noble, J.A. & Grannis, F.W. (1984). Acute esophageal obstruction by a psyllium-based bulk laxative. Chest, 86, 800.

Nozaki, S., Saito, T., Matsumura, T., Miyai, I. & Kang, J. (1999). [Relationship between weight loss and dysphagia in patients with Parkinson's disease]. Rinsho-Shinkeigaku, 39, 1010-4.

Ordre des diététistes du Québec. (2000). Manuel de Nutrition Clinique. Chapitre 16.4. Ordre des diététistes du Québec, Montreal, QC.

Ontario Ministry of Health. (2004). Standards: B. Resident Care and Services & Dietary Service, Standards and Criteria: Nutrition and Hydration Consultation Draft. Toronto, ON: Ontario Ministry of Health and Long Term Care.

Patrick, P.G., Gohman, S.M., Marx, S.C., Delegge, M.H. & Greenberg, N.A. (1998). Effect of supplements of partially hydrolyzed guar gum on the occurrence of constipation and use of laxative agents. Journal of the American Dietetic Association, 98, 912-914.

Payette, H., Coulombe, C., Boutier, V. & Gray-Donald, K. (1999). Weight loss and mortality among free-living frail elders: a prospective study. Journal of Gerontology, 54A, M440-445.

Payette, H., Gray-Donald, K. & Cyr, R. (1995). Predictors of dietary intakes in Independent free-living elderly population. American Journal of Public Health, 85, 677-683.

Pedersen, A., Sandstrom, B. & van Amelsvoort, J.M. (1997). The effect of ingestion of inulin on blood lipids and gastrointestinal symptoms in healthy females. British Journal of Nutrition, 78, 215-22.

Penman, J.P. & Thomson, M. (1998). A review of the textured diets developed for the management of dysphagia. Journal of Human Nutrition and Dietetics, 11, 51-60.

Phillips, J, Muir, J.G., Birkett, A., Lu, Z., Jones, G.P., O'Dea, K. & Young, G.P. (1995). Effect of resistant starch on fecal bulk and fermentation-dependent: a pilot study. Journal of the American Dietetic Association, 62, 121-130.

Pietinen, P., Rimm, E.B., Korhonen, P., Hartman, A.M., Willett, W.C., Albanes, D. & Virtamo, J. (1996). Intake of dietary fiber and risk of coronary heart disease in a cohort of Finnish men. The Alpha-Tocopherol, Beta-Carotene Cancer Prevention Study. Circulation, 94, 2720-2727.

Poste, L.M., Mackie, D.A., Butler, G. & Larmond, E. (1991). Laboratory Methods for Sensory Analysis of Food. Ottawa, ON: Agriculture Canada.

Poucherot, C. & Issanchou, S. (1998). Dynamics of liking for flavoured crackers: Test of predictive value of a boredom test. Food Quality and Preference, 9, 21-29.

Pouderoux, P. & Kahrilas, P.J. (1995). Deglutive tongue force modulation by volition, volume, and viscosity in humans. Gastroenterology, 108, 1418-26.

Preston, A.J., Gosney, M.A., Noon, S. & Martin, M.V. (1999). Oral flora of elderly patients following acute medical admission. Gerontology, 45, 49-52.

Prinz, J.F. & Lucas, P.W. (1997). An optimization model for mastication and swallowing in mammals. Proceedings of the Royal Academy of London, Series B, Biological sciences, 264(1389), 1715-21.

Prinz, J.F. & Lucas, P.W. (1995). Swallow thresholds in human mastication. Archives of Oral Biology, 40, 401-3.

Quail, F.A. (1998). Easing the strain of constipation. Canadian Journal of Continuing Medical Education, Dec, 117-124

Rajala, S.A., Salminen, S.J., Seppãnen, J.H. & Vapaatalo, H. (1988). Treatment of chronic constipation with lactitol sweetened yoghurt supplemented with guar gum and wheat bran in elderly hospital in-patients. Comprehensive Gerontology. Section A, Clinical and Laboratory Sciences, 2, 83-86.

Raut, V.V., McKee, G.J. & Johnston, B.T. (2001). Effect of bolus consistency on swallowing--does altering consistency help? European Archives of Oto-Rhino-Laryngology, 258, 49-53.

Read, N.W., Celik, A.F. & Katsinelos, P. (1995). Constipation and incontinence in the elderly. Journal of Clinical Gastroenterology, 20, 61-70.

Rimm, E.B., Ascherio, A., Giovannucci, E., Spiegelman, D., Stampfer, M.J. & Willet W.C. (1996). Vegetable, fruit, and cereal fiber intake and risk of coronary heart disease among men. Journal of the American Medical Association. 275, 447-451.

Ripsin, C.M., Keenan, J.M., Jacobs, D.R., Elmer, P.J., Welch, R.R., Van Horn, L., Liu, K., Turnbull, W.H., Thye, F.W., Kestin, M., Hegsted, M., Davidson, D.M., Davidson, M.H., Dugan, L.D., Demark-Wahnefried, W. & Beling, S. (1992). Oat products and lipid lowering. A meta-analysis. Journal of the American Medical Association, 267, 3317-3325.

Roberfroid, M. (1993). Dietary fiber, inulin and oligofructose: A review comparing their physiological effects. Critical Reviews in Food Science & Nutrition, 33, 103-148.

Roediger, W.E.W. (1980). The colonic epithelium in ulcerative colitis: An energy-deficiency disease? Lancet, 2, 712-715.

Roediger, W.E.W. (1982). Utilization of nutrients by isolated epithelial cells of the rat colon. Gastroenterology, 83, 424-429.

Roediger, W.E., Duncan, A., Kapaniris, O. & Millard, S. (1993). Reducing sulfur compounds of the colon impair colonocyte nutrition: Implications for ulcerative colitis. Gastroenterology, 104, 424-429.

Rodrigues-Fisher, L., Bourguignon, C. & Good, B.V. (1993). Dietary fiber nursing intervention: Prevention of constipation in older adults. Clinical Nursing Research, 2, 464-477.

Romero, Y., Evans, J.M., Fleming, K.C. & Phillips, S.F. (1996). Constipation and fecal incontinence in the elderly population. Mayo Clinic Proceedings, 71, 81-92.

Roe, D.A. (1986). Drug-nutrient interactions in the elderly. Geriatrics, 41, 57-59, 63-64, 74.

Rutgers, G. (1958). The consistency of starch-milk puddings. I. Preparation of puddings and measurement of consistency. Journal of Science Food and Agriculture, 9, 61-68.

Salmerón, J., Ascherio, A., Rimm, E.B., Colditz, G.A., Spiegelman, D., Jenkins, D.J., Stampfer, M.J., Wing, A.L. & Willett, W.C. (1997). Dietary fiber, glycemic load, and risk of NIDDM in men. Diabetes Car, 20, 545-550.

Salmerón, J., Manson, J.E., Stampfer, M.J., Colditz, G.A., Wing, A.L. & Willett W.C. (1997). Dietary fiber, glycemic load, and risk of NIDDM in women. Journal of the American Medical Association, 277, 472-477.

Sandman, P.O., Adolfsson, R. & Hallsman, G. (1983). Treatment of constipation with high bran bread in long term care of severely demented elderly patients. Journal American Geriatric Society, 31, 289-93.

Saskatchewan Health. (2002). 2001-2002 Year End Report. Saskatoon District Health. unpublished data.

Schaeffer, D.C. & Cheskin, L.J. (1998). Constipation in the elderly. American Family Physicians, 58, 907-914.

Schiffman, S.S. (1987). Taste. In: Maddox, GL, ed. Encyclopedia of aging. Springer: New York, NY.

Schiffman, S.S. (1983). Taste and smell in disease. New England Journal of Medicine, 308, 1275-1279.

Schiffman, S.S. & Pasternak, M. (1979). Decreased discrimination of food odors in the elderly. Journal of Gerontology, 34, 73-79.

Schiffman, S.S. & Warwick, Z.S. (1993). Effect of flavor enhancement of foods for the elderly on nutritional status: food intake, biochemical indices, and anthropometric measures. Physiology & Behavior, 53, 395-402.

Sefa-Dedeh, S. (1989). Effects of particle size on some physiochemical characteristics o'agbelima'(cassava dough) and corn dough. Tropical Science, 29, 21-32.

Selig, H., & Boyle, J. (2001). Dietary intervention. Bowel care and maintenance in long-term care. The Canadian Nurse, 97, 28-33.

Simmons, K. (1986). Dysphagia management means diagnosis, exercise, reeducation. Journal of the American Medical Association, 255, 3209-10, 3212.

Shay, K. (2002). Infectious complications of dental and periodontal diseases in the elderly population. Clinical Infectious Diseases an Official Publication of the Infectious Diseases Society of America, 34, 1215-23.

Slavin, J. (1987). Dietary fibre: Classification, chemical analysis, and food sources. Journal of the American Dietetic Association, 87, 1164-1171.

Smith, T., Brown, J.C. & Livesey, G. (1998). Energy balance and thermogenesis in rats consuming nonstarch polysaccharides of various fermentabilities. American Journal of Clinical Nutrition, 68, 802-819.

Sonies, B.C. (1999). Disease State Management: Dysphagia. Proceedings of the fourth Annual Ross Medical Nutrition and Device Roundtable. Charleston, SC April 26-28, 1999. Silver Spring, MD: Supplement to Nutrition in Clinical Practice, ASPEN.

Stacewicz-Sapuntzakis, M., Bowen, P.E., Hussein, E.A., Damayanti-Wood, B.I. & Farnsworth, N.R. (2001). Chemical composition and potential health effects of prunes: a functional food? Critical Reviews of Food Science and Nutrition, 41, 251-86.

Stewart, E., Mackenzie, J. & Downie, G. (1997). A strategy to reduce laxative use among older people. Nursing Times, 93(4), 35-36.

Steele, C.M., Greenwood, C., Ens, I., Robertson, C. & Seidman-Carlson, R. (1997). Mealtime difficulties in a home for the aged: not just dysphagia. Dysphagia, 12, 43-50; discussion 51.

Steingold, G. & Vartan, K. (1991). The last frontier: satisfying food for everyone. Nursing Homes and Senior Citizen Care, 40, 21-24.

Stephen, A.M., Dahl, W.J., Johns, D.M. & Englyst, H.N. (1997). Fermentability of oat hull fibre in the human colon and its effects on colonic function and serum lipids. Cereal Chemistry, 74, 379-83.

Stephen, A.M., Morgan, D.R., Dahl, W.J. & Nickel, G.G. (1992). The effect of isolated pea hull fibre on human colonic function. Gastroenterology. 102, A579.

Stewart, E., Mackenzie, J. & Downie, G. (1997). A strategy to reduce laxative use among older people. Nursing Times, 93, 35-36.

Stone-Dorshow, T. & Levitt, M.D. (1987). Gaseous response to ingestion of a poorly absorbed fructo-oligosaccharide sweetener. American Journal of Clinical Nutrition, 46, 61-65.

Sullivan, D.H., Sun, S. & Walls, R.C. (1999). Protein-energy undernutrition among elderly hospitalized patients. Journal of the American Medical Association, 281, 2013-2019.

Swanson, K.S., Grieshop, C.M., Flickinger, E.A., Healy, H.P., Dawson, K.A., Merchen, N.R., Fahey, G.C. Jr. (2002). Effects of supplemental fructooligosaccharides plus mannanoligosaccharides on immune function and ileal and fecal microbial populations in adult dogs. Archiv fur Tierernahrung, 56, 309-18.

Szczesniak, A.S., Brandt, M.A. & Friedman, H.H. (1963). Development of standard rating scales for mechanical parameters of texture and correlation between the objective and the sensory methods of texture evaluation. Journal of Food Science, 28, 397-403.

Talley, N.J., O'Keefe, E.A., Zinsmeister, A.R. & Melton, L.J. 3rd. (1992). Prevalence of gastrointestinal symptoms in the elderly: A population-based study. Gastroenterology, 102, 895-901.

Tinker, L.F., Schneeman, B.O., Davis, P.A., Gallaher, D.D. & Waggoner, C.R. (1991). Consumption of prunes as a source of dietary fibre in men with mild hypercholesterolemia. American Journal of Clinical Nutrition, 53, 1259-65.

Tomlin, J., Lowis, C. & Read, N.W. (1991). Investigation of normal flatus production in healthy volunteers. Gut, 32, 665-669.

Towers, A.L., Burgio, K.L., Locher, J.L., Merkel, I.S., Sataeian, M. & Wald, A. (1994). Constipation in the elderly: Influence of dietary, psychological, and physiological factors. Journal of the American Geriatric Society, 1994, 42, 701-706.

Tuohy, K.M., Kolinda, S., Lustenberger, A.M. & Gibson, G.R. (2001). The prebiotic effects of biscuits containing partially hydrolysed guar gum and fructo-oligosaccarides-A human volunteer study. British Journal of Nutrition, 86, 341-348.

Vache, C., Rousset, P., Gachon, P., Gachon, A.M., Morio, B., Boulier, A., Coudert, J., Beaufrere, B. & Ritz, P. (1998). Bioelectric impedance analysis measurements of total body water and extracellular water in healthy elderly subjects. International Journal of Obesity, 22, 537-543.

Van Dokkum. W., Wezendonk, B., Srikumar, T.S. & van den Heuvel, E.G.H.M. (1999). Effect of nondigestable oligosaccharides on large-bowel functions, blood lipid concentrations and glucose absorption in young healthy male subjects. European Journal of Clinical Nutrition, 53, 1-7.

Van Soest, P. and Wine, R.H. (1967). Use of detergents in the analysis of fibrous feeds. IV. Determination of plant cell wall constituents. Journal of Official Agricultural Chemists, 50, 50-55

Ward, F.M. (1999). Guar specialty products as thickeners and fibre sources. Cereal Foods World, 44, 638-641.

Wendland, B.E., Greenwood, C.E., Weinberg, I. &Young, K.W. (2003). Malnutrition in institutionalized seniors: the iatrogenic component. Journal of the American Geriatrics Society, 51, 85-90.

Williams, M.J. & Walker, G.T. (1992). Managing swallowing problems in the home. Caring Magazine, 11, 59-63.

Williams, C.H., Witherly, S.A. & Buddington, R.K. (1994). Influence of dietary neosugar on selected bacterial groups of the human faecal microbiota. Microbial Ecology in Health and Disease, 7, 91-97.

Wilson, J.A.P. (1999). Constipation in the elderly. Clinical Geriatric Medicine. 15, 499-510.

Wolever, T.M.S. & Jenkins, D.J.A. (1993). Effect of dietary fiber and foods on carbohydrate metabolism. In Spiller G, ed. CRC Handbook of Dietary Fiber in Human Nutrition. Boca Raton, FL: CRC Press.

Wolfsen, C.R., Barker, J.C. & Mitteness, L.S. (1993). Constipation in the daily lives of frail elderly people. Archives of Family Medicine, 2, 853-858.

Wolk, A., Manson, J.E., Stampfer, M.J., Colditz, G.A., Hu, F.B., Speizer, F.E., Hennekens, C.H. & Willett, W.C. (1999). Long term intake of dietary fibre and decreased risk of coronary heart disease among women. Journal of the American Medical Association, 281, 1998-2004.

Wright, B.A. & Jeffrey, P.H. (1990). Lipoid pneumonia. Seminars in Respiratory Infection, 5, 314-21.

APPENDIX A

The Effects of Finely Processed Pea Hull Fibre on Laxative Use, Food Acceptance and Quality of Life of Long term Care Residents

Purpose: To study the effects of adding dietary fibre from finely processed pea hull on laxative use, food acceptance and quality of life of long term care residents.

Benefits: The results obtained will provide valuable information as to whether increasing the fibre content of the usual foods of long term care diets will improve bowel care of residents. The increased fibre may result in more frequent bowel movements, softer stools and easier passage of stools.

Side Effects: The amount of dietary fibre to be added to the diets will not result in an intake greater than recommended. Possible side effects of increasing fibre intake are gas production and bloating. Adequate fluid intake is recommended when consuming a high fibre diet.

In consenting to participate in this study, I understand and agree with the following statements:

1. I consent to consume prepared cookies, puddings and other food items that contain pea hull fibre. These foods will be freely offered as snacks or with meals and I am not required to eat them if I do not want to.
2. I have been able to ask any questions I want about the study, which have been answered to my satisfaction.
3. I understand that I am ensured my privacy and anonymity; my identity will remain confidential if the results are published.
4. I understand that I am free to withdraw from participating in the study at anytime, without penalty. The withdrawal or the decision not to participate will not affect my care or the services I receive. I will have access to foods not containing the fibre source.

Contacts: If you have any questions with regards to this research project, please do not hesitate to contact any of the researchers below:

Wendy Dahl 966 5831 (work) 329 4775 (home)

Sherri Hildebrandt 664 0324 (work)

Dr. Susan Whiting 966 5637 (work) 477-0214 (home)

I hereby acknowledge that the contents of the consent have been explained to me and that I have received a copy of the consent for my own records.

____________________________ ______________

Signature of Resident Date

Signature of Research Coordinator Date

Signature of Witness Date

APPENDIX B

University of Saskatchewan
Advisory Committee on Ethics in Human Experimentation

December 21, 2000

Certificate of Approval

PRINCIPAL INVESTIGATOR	DEPARTMENT	BMC#
S. Whiting (W. Dahl)	Pharmacy and Nutrition	2000-248

INSTITUTION(S) WHERE RESEARCH WILL BE CARRIED OUT

Luther Special Care Home, Saskatoon

SPONSORING AGENCIES

Saskatchewan Pulse Crop Development Board

TITLE:

The Effects of Finely Processed Pea Hull Fibre on Laxative Use, Food Acceptance and Quality of Life of Long Term Care Residents

ORIGINAL APPROVAL DATE	EXPIRY DATE
December 21, 2000	January 1, 2002

CERTIFICATION

The University Advisory Committee on Ethics in Human Experimentation (UACEHE) has reviewed the above-named research project including the protocol and consent form, if applicable. The proposal was found to be acceptable on ethical grounds. The principal investigator has the responsibility of ensuring that the authorized research is carried out according to governing law. This Certificate of Approval is valid for the above time period provided there is no change in experimental procedures.

ONGOING REVIEW REQUIREMENT(S)

The UACEHE will require the submission of an annual status report at least **one month** prior to the expiry date.

APPROVED.

D.W. Quest, Chair
University Advisory Committee on
Ethics in Human Experimentation

APPENDIX C

Fibre Study: Resident Survey

1. How would you rate the food over the past few weeks?

   Comments:

☐ Excellent ☐ Good ☐ Fair ☐ Poor ☐ Don't Know

2. Did you notice any change in the food in the past five weeks?

   ☐Yes ☐ No

If yes….

3. Did you notice a change in the taste of the food. ☐Yes ☐ No

   (If yes)How did the taste change?

4. Did you notice a change in the texture of the food. ☐Yes ☐ No

   (If yes)How did the texture change?

5. Did you notice a change in the aroma of the food. ☐Yes ☐ No

   (If yes)How did the aroma change?

6. Have you noticed a change in your bowel habits over the last few weeks?

   ☐Yes ☐ No

   (If yes) How have your bowel habits changed over the past few weeks?

APPENDIX D

Fibre Study: Dietary Survey

During the past six weeks, Lutheran Special Care Home has been the site of a research study. In this study, we have added finely processed fibre to various foods served throughout the day for the purpose of improving the bowel function of residents. We would like your thoughts and opinions about the study. If you could take about 5 minutes to fill out the following questionnaire, we would find the information very useful.

Thank you for your help.

1. Did you know about the study?

□Yes □No

2. Compared to the usual, how has your **workload** been affected by the study?

□ Increased □ Decreased □ No change

3. Compared to the usual, how has the **resident's acceptance of the food** been affected by the study?

□ Increased □ Decreased □ No change

4. Compared to the usual, how has the amount of **food waste** been affected by the study?

□ Increased □ Decreased □ No change

5. How would you rate the success of this study with regards to food acceptance?

□ Very successful □ Somewhat successful □ Not successful

Why/why not?

6. What would you like to see happen next?

□ Continue to add same amount of fibre □ Add more fibre

□ Add less fibre □ Stop adding fibre

7. Please provide any additional comments.

APPENDIX E

Technical information on Exlite® pea hull fibre*

Compositional Analysis	%
Total Dietary Fibre	82
Soluble Dietary Fibre	7
Insoluble Dietary Fibre	75
Moisture	8
Protein (N x 6.25)	9
Fat	< 0.5
Ash	
Physical Data	3
Flavour	Bland
Color	Off white
Particle Size (140 mesh)	>95%
Microns (106)	>95%

Mineral Content	**mg/100g**
Calcium	334
Iron	13

* Reproduced with permission from Parrheim Foods, Saskatoon, SK.

APPENDIX F

Technical information on Centara III® pea hull fibre.*

Composition (dry matter basis)

Moisture	(16 hrs ± 100°C ± 5°C)	<8.0%
Protein	(Kjeldahl, N x 6.25)	<6.0%
Fat	(AOAC 7.060, 14th Ed)	<0.5%
Ash	(AOAC 14.006, 14th Ed)	<2.0%
Total Dietary Fiber	(AOAC 43-A14, 14th Ed)	>90.0%
pH	(10% solution)	neutral

Physical Data

Flavour	neutral
Colour	off-white
Particle Size (through a 120 mesh Tyler)	>95%
Microns	125

Microbiology

Total Plate Count (AOAC 46.015, 14th Ed)	<30,000/g
E.coli (AOAC 46.016, 14th Ed)	negative
Salmonella (AOAC 46.117, 14th Ed)	negative
Yeasts and Moulds (AOAC 997.02, 16th Ed)	<100/g

Minerals

Sodium	930 ppm
Potassium	830 ppm
Magnesium	3030 ppm
Calcium	5200 ppm
Phosphorus	601 ppm
Manganese	8 ppm
Iron	43 ppm
Zinc	15 ppm
Copper	<1 ppm

* Reproduced with permission from Parrheim Foods, Portage la Prairie, MB.

APPENDIX G

Basic Bread Machine Formulation		Enhanced
Water	375 g	425 g
Powder skim milk	10 g	10 g
Shortening	30 g	30 g
Sugar	45 g	45 g
Salt	6.5 g	6.5 g
Flour (Best for Bread)	300 g	267.2 g
Flour (All-purpose)	320 g	287.2g
Pea hull fibre	0 g	65.6 g
Bread Machine Yeast	7 g	7 g
Total	1093.5 g	1143.5 g

Fibre usage 1.5g/25g slice

Sensory Short Cake		Enhanced
All-purpose flour	200 g	168 g
Pea hull fibre	0 g	32 g
Sugar	160 g	160 g
Powder skim milk	22 g	22 g
Salt	4 g	4 g
Baking Powder	11.5 g	11.5 g
Vanilla	5 g	5 g
Water	160 g	185 g
Butter (softened)	75 g	75 g
Eggs (2)	100 g	100 g
Total	737.5 g	762.5 g

Fibre usage: 8" x 8" pan serving size: 2" x 2"
16 servings/ pan 2 g/serving = 32 g fibre

Short-bread Cookies		**Enhanced**
All-purpose flour	155 g	117 g
Pea hull fibre	0	38 g
Cornstarch	70 g	70 g
Icing sugar	80 g	80 g
Butter (room temperature)	170 g	170 g
Water	0 g	25 g
Total	475 g	500 g

Fibre usage: 2 g fibre/ 25 g cookie (raw)

Basic Muffin		**Enhanced**
All-purpose flour	225 g	202 g
Pea hull fibre	0 g	23 g
Sugar	80 g	80 g
Whole egg powder	13.5 g	13.5 g
Vegetable oil	50 g	50 g
Butter (melted)	30 g	30 g
Baking powder	10 g	10 g
Powder skim milk	17 g	17 g
Salt	2 g	2 g
Vanilla	4 g	4 g
Water	175 g	200 g
Total	606.5 g	631.5 g

Fibre usage: 3 g fibre/ 80 g serving

APPENDIX H

University of Saskatchewan
Biomedical Research Ethics Board (Bio-REB)

02-Jun-2004

Certificate of Approval

PRINCIPAL INVESTIGATOR	DEPARTMENT	BMC #
R. T. Tyler	Applied Microbiology and Food Science	03-994

INSTITUTION (S) WHERE RESEARCH WILL BE CARRIED OUT

Saskatoon District Health
Saskatoon SK

University of Saskatchewan
Saskatoon SK

SUB-INVESTIGATOR(S)

Wendy J. Dahl
Susan J. Whiting

SPONSORING AGENCIES

AGRICULTURAL DEVELOPMENT FUND

TITLE:

Sensory Evaluation of Pea Hull Fibre Fortified Baked Goods

ORIGINAL APPROVAL DATE	CURRENT EXPIRY DATE	APPROVAL OF
02-Jun-2003	01-Jun-2004	Protocol and consent form as submitted

CERTIFICATION

The University of Saskatchewan Biomedical Research Ethics Board has reviewed the above-named research project at a full-board meeting (any research classified as minimal risk is reviewed through the expedited review process). The proposal was found to be acceptable on ethical grounds. The principal investigator has the responsibility for any other administrative or regulatory approvals that may pertain to this research project, and for ensuring that the authorized research is carried out according to governing law. This Approval is valid for the above time period provided there is no change in experimental protocol or in the consent process.

ONGOING REVIEW REQUIREMENTS/REB ATTESTATION

In order to receive annual renewal, a status report must be submitted to the Chair for Committee consideration within one month of the current expiry date each year the study remains open, and upon study completion. Please refer to the following website for further instructions: http://www.usask.ca/research/ethics.shtml. In respect to clinical trials, the University of Saskatchewan Research Ethics Board complies with the membership requirements for Research Ethics Boards defined in Division 5 of the Food and Drug Regulations and carries out its functions in a manner consistent with Good Clinical Practices. This approval and the views of this REB have been documented in writing.

Barry D. McLennan, Ph.D., Chair
University of Saskatchewan
Biomedical Research Ethics Board

APPENDIX I

Participant Information and Consent Form April 24th, 2003

Wendy Dahl, PhD student in the College of Pharmacy and Nutrition and Shannon Hood, MSc student in the Department of Applied Microbiology and Foods Science, College of Agriculture, University of Saskatchewan are conducting a study of the acceptability of baked goods prepared with pea hull fibre.

Study Title: **Sensory evaluation of pea hull fibre fortified baked goods.**

Benefits: There may be no direct benefit to participating in this study. You are being asked to participate in this study because of your experience in sensory evaluation.

Procedures:

1. You will be asked to taste pea hull fibre containing bread, muffin and cookie.
2. You will be asked to rank sensory attributes of pea hull fibre bread, muffin and cookie.

The taste testing will be carried out by the researchers and staff of the Product Development Lab in the College of Agriculture. Each sensory evaluation session will take about fifteen minutes.

Confidentiality:

While absolute confidentiality cannot be guaranteed, every effort will be made to ensure that the information you provide for this study is kept entirely confidential. Your name will not be attached to any information, nor mentioned in any study report, nor be made available to anyone except the research team.

Participation is Voluntary:

Your participation in this study is entirely voluntary. You have the right to refuse to participate and to withdraw from the study at any time, for any reason.

Potential Risks:

If you have food allergies to foods in this study you are not permitted to participate. There is the possibility of unforeseen risks during and following the study.

Research Related Injury:

There will be no costs to you for participation in this study. You will not be charged for any research procedures. In the event that you become ill or injured as a result of participating in this study, necessary medical treatment will be made available at no cost to you.

Compensation:

You will not receive an honorarium for participating in this study.

Contacts:

If you have any questions with regards to this research project, please do not hesitate to contact the researchers below:

Wendy Dahl	966 2179
Shannon Hood	966 2179

If you have any questions about your rights as a research subject, you may contact the chair of the Biomedical Ethics Board, c/o the Office of Research Services, University of Saskatchewan at (306) 966 4053.
The contents of this consent form have been explained to me. I have been able to ask questions about the study and these questions have been answered to my satisfaction. I have received a copy of the consent form for my own records.

SIGNATURES
Participant: ______________________________ Date: __________________

Research Coordinator: _____________________ Date: _________________

Witness: _________________________________ Date: _________________

APPENDIX J

Sensory Analysis of Fibre-enhanced Baked Products

Food Product: Shortbread Cookie/Cake
Sample code #_______________
Please circle the number that most closely represents your interpretation.

Appearance
1__________2__________3__________4__________5
unacceptable highly acceptable

Texture
1__________2__________3__________4__________5
unacceptable highly acceptable

Mouthfeel
1__________2__________3__________4__________5
unacceptable highly acceptable

Flavour
1__________2__________3__________4__________5
unacceptable highly acceptable

Moistness
1__________2__________3__________4__________5
unacceptable highly acceptable

Overall Acceptability
1__________2__________3__________4__________5
unacceptable highly acceptable

Comments:

APPENDIX K

ATTENTION: **HEAD COOK/FOOD SERVICE SUPERVISOR**
SPECIAL CARE HOMES IN SASKATCHEWAN

RE: **PREPARATION OF PUREED FOODS HIGH IN STARCH**
COLLEGE OF PHARMACY AND NUTRITION,
UNIVERSITY OF SASKATCHEWAN

The purpose of this survey is to study the extent of preparation of pureed foods with high starch content that occurs in special care homes in Saskatchewan. We request your participation in answering the following questions and faxing your response back to us at the College of Pharmacy and Nutrition, University of Saskatchewan at **(306) 966-6377** by June 30, 2003. Your cooperation is greatly appreciated.

Sincerely,
Wendy Dahl and Heather Balogh
College of Pharmacy and Nutrition, University of Saskatchewan

1. Are pureed foods high in starch content served at your special care home?
Yes/No
If so, which of the following foods are prepared for residents on pureed diets:

___ breads ___ potatoes ___ rice
___ pasta ___ pancakes ___cookies/cake
___ cereal ___other (provide example):________________

2. How often are pureed foods high in starch prepared and served at your special care home?

Pureed bread:
___ never
___ rarely
___ once weekly
___ once daily
___at every meal
___other (indicate frequency):
____

Pureed pasta:
___ never
___ rarely
___once weekly
___ once daily
___ at every meal
___ other (indicate frequency):
____

Pureed rice:
___ never
___ rarely
___ once weekly
___ once daily
___at every meal
___other (indicate frequency):
____

Pureed cereal:
___ never
___ rarely
___once weekly
___ once daily
___ at every meal
___ other (indicate frequency):
____

Pureed pancakes:
___ never
___ rarely

Pureed potatoes:
___ never
___ rarely

___ once weekly
___ once daily
___at every meal
___other (indicate frequency):
____

___once weekly
___ once daily
___ at every meal
___ other (indicate frequency):
____

Pureed cookies/cake:
___ never
___ rarely
___ once weekly
___ once daily
___at every meal
___other (indicate frequency):
____

Others (as indicated in question 1):
___ never
___ rarely
___once weekly
___ once daily
___ at every meal
___ other (indicate frequency):
____

3. If any of the foods from Question 1 are not prepared and served or are rarely prepared and served at your special care home, please state the reasons.

4. Optional: We are also interested in obtaining any recipes of foods high in starch that have been pureed successfully and have high resident acceptability. If you have any recipes you would like to share, please mail them to: Heather Balogh, 110 Science Place, College of Pharmacy and Nutrition, University of Saskatchewan, Saskatoon, SK, S7N 5C9.

THANK YOU!

APPENDIX H

University of Saskatchewan
Biomedical Research Ethics Board (Bio-REB)

02-Jun-2004

Certificate of Approval

PRINCIPAL INVESTIGATOR	DEPARTMENT	BMC #
R. T. Tyler	Applied Microbiology and Food Science	03-994

INSTITUTION (S) WHERE RESEARCH WILL BE CARRIED OUT

Saskatoon District Health Saskatoon SK	University of Saskatchewan Saskatoon SK

SUB-INVESTIGATOR(S)

Wendy J. Dahl
Susan J. Whiting

SPONSORING AGENCIES

AGRICULTURAL DEVELOPMENT FUND

TITLE:

Sensory Evaluation of Pea Hull Fibre Fortified Baked Goods

ORIGINAL APPROVAL DATE	CURRENT EXPIRY DATE	APPROVAL OF
02-Jun-2003	01-Jun-2004	Protocol and consent form as submitted

CERTIFICATION

The University of Saskatchewan Biomedical Research Ethics Board has reviewed the above-named research project at a full-board meeting (any research classified as minimal risk is reviewed through the expedited review process). The proposal was found to be acceptable on ethical grounds. The principal investigator has the responsibility for any other administrative or regulatory approvals that may pertain to this research project, and for ensuring that the authorized research is carried out according to governing law. This Approval is valid for the above time period provided there is no change in experimental protocol or in the consent process.

ONGOING REVIEW REQUIREMENTS/REB ATTESTATION

In order to receive annual renewal, a status report must be submitted to the Chair for Committee consideration within one month of the current expiry date each year the study remains open, and upon study completion. Please refer to the following website for further instructions: http://www.usask.ca/research/ethics.shtml. In respect to clinical trials, the University of Saskatchewan Research Ethics Board complies with the membership requirements for Research Ethics Boards defined in Division 5 of the Food and Drug Regulations and carries out its functions in a manner consistent with Good Clinical Practices. This approval and the views of this REB have been documented in writing.

Barry D. McLennan, Ph.D., Chair
University of Saskatchewan
Biomedical Research Ethics Board

APPENDIX M

Particle Size Determination

Total dried weight of a sample

1. Weigh a 50grams+/- 0.25g sample in a aluminum rectangle dish (10.5cm x 12.5 cm) after weighting the dish.
2. Put into the drying oven for 7 hours at 100 C to determine the weight of the dried pureed sample.
3. Weigh the dried sample, and determine the total dried weight (don't forget to deduct the dish weight).

Weight of each size of particle

4. Prepare 1 or 2 samples of 50 g +/- 0.25g, as prepared, at room temperature
5. Prepare the stack of standard Tyler sieves with the 5 different mesh screen sizes: 1.00 mm, 850 μm, 600 μm, 300 μm, 212 μm, if there is a significant product at 1mm, begin with a new sample using 2mm.
6. Using a continuous jet of distilled water, spray each screen for 2 minutes through sieves.
7. Wash each screen in a big bowl (bigger than the screen) with distilled water to recover all the particles.
8. Slowly pour the contents of each bowl in an Erylmeyer flask covered by a funnel and a filter paper (Whatman #4). Filter the liquid through filter paper thereby trapping the particles on the paper.
9. Put the 5 filter papers containing particles + 1 wet paper filter (blank) into the oven for 30 minutes at 100 C.
10. Weigh the dried filter papers.
11. The weight of the sample is then calculated.
12. The solid content that passes through the bottom sieve is determined by difference.

Table M.1. Dried weight (g) of particles collected on various screen mesh sizes of pureed foods prepared at Parkridge.

	Wt (g)	Dried wt (g)	sieve 2.00 mm (g)	sieve 1.00 mm (g)	sieve 850 µm (g)	sieve 600 µm (g)	sieve 300 µm (g)	sieve 212 µm (g)	Sieve <212 µm (g)
Pureed Potato	49.9	7.6	/	1.43	0.07	0.48	1.81	1.12	2.69
Pureed Beef	50.0	11.7	0.05	0.14	0.04	0.1	0.66	0.71	10.00
Pureed Pea	50.1	8.1	/	4.65	0.07	0.17	0.19	0.07	2.95
Pureed Turkey	50.1	14.2	3.42	4.84	0.82	0.33	1.08	0.64	3.10
Pureed Pork	50.1	12.2	/	0.3	0.11	0.28	4.75	0.9	5.86
Pureed Chicken	50.0	17.1	1.48	3.22	0.17	0.76	1.3	0.52	9.65
Carrots Puree	50.1	4.1	/	0.30	0.05	0.24	1.02	0.15	2.34
Mean	**50.0**	**10.7**	**/**	**2.1**	**0.2**	**0.3**	**1.5**	**0.6**	**5.2**

Table M.2. Percentage of particles collected on screens of various mesh sizes of pureed foods prepared at Parkridge Center.

	sieve 1.00 mm (%)	sieve 850 µm (%)	sieve 600 µm (%)	Sieve 300 µm (%)	sieve 212 µm (%)	sieve <212 µm (%)
Pureed Potato	18.7	0.92	6.28	23.7	15.0	35.4
Pureed Beef	1.2	0.34	0.85	5.64	6.1	85.5
Pureed Pea	57.3	0.86	2.09	2.34	0.9	36.4
Pureed Turkey	34.1	5.78	2.33	7.62	4.5	21.8
Pureed Pork	2.5	0.9	2.29	38.8	7.4	48.0
Pureed Chicken	18.9	1	4.46	7.62	3.0	56.4
Carrots Puree	7.3	1.21	5.8	24.6	3.6	57.1
Mean	**20.0**	**1.6**	**3.4**	**15.8**	**5.1**	**48.7**

Table M.3. Dried weight (g) of particles collected on various screen mesh sizes of pureed foods prepared at Luther Special Care Home.

	Wt (g)	Total dried wt (g)	sieve 2.00 mm (g)	sieve 1.00 mm (g)	Sieve 850 µm (g)	sieve 600 µm (g)	Sieve 300 µm (g)	Sieve 212 µm (g)	sieve <221 µm (g)
Danish Pork Chop	50.20	11.82	-	2.68	0.06	0.47	0.94	0.35	7.32
Chili	49.88	12.83	-	1.12	0.16	0.69	2.08	0.59	8.19
Turkey a la King	49.93	10.31	-	3.57	0.11	0.22	0.68	0.25	5.48
Mean	**50.00**	**11.7**	**-**	**2.5**	**0.1**	**0.5**	**1.2**	**0.40**	**7.0**

Table M.4. Percentage of particles collected on screens of various mesh sizes of pureed foods prepared at Luther Special Care Home.

	sieve 1.00 mm (%)	sieve 850 µm (%)	sieve 600 µm (%)	sieve 300 µm (%)	Sieve 212 µm (%)	sieve <212 µm (%)
Danish Pork Chop	22.70	0.51	3.98	7.95	2.96	61.9
Chili	8.73	1.25	5.38	16.2	4.60	63.8
Turkey a la King	34.60	1.07	2.13	6.6	2.42	53.2
Mean	**22.0**	**0.9**	**3.8**	**10.3**	**3.3**	**59.6**

Table M.5. Dried weight (g) of particles collected on various screen mesh sizes of commercial baby food.

Pureed Food	Wet Wt. (g)	Total dried wt. (g)	% dried wt. (g)	sieve 1.00 mm (g)	Sieve 850 µm (g)	sieve 600 µm (g)	sieve 300 µm (g)	sieve 212 µm (g)	sieve <212 µm (g)
Carrot 1	49.96	2.27	4.56	0.12	0.14	0.11	0.82	0.13	0.95
Carrot 2	50.17	2.27	4.56	0.11	0.10	0.09	0.28	0.49	1.20
Peas 1	50.21	7.05	14.13	0.07	0.08	0.08	0.71	0.18	5.93
Peas 2	49.78	7.05	14.13	0.03	0.05	0.08	0.54	0.21	6.14
Corn 1	49.83	5.90	11.81	0.68	0.17	0.28	0.47	0.24	4.06
Corn 2	49.85	5.90	11.81	0.36	0.18	0.23	0.38	0.24	4.51
Chicken	50.28	11.74	23.50	0.05	0.05	0.02	0.13	0.17	11.30
Mean	**50.0**	**6.7**	**13.4**	**0.2**	**0.1**	**0.3**	**0.7**	**0.3**	**5.1**

Table M.6. Percentage of particles collected on screens of various mesh sizes of baby foods.

Pureed Food	sieve 1.00 mm (%)	Sieve 850 Mm (%)	sieve 600 µm (%)	sieve 300 µm (%)	sieve 212 µm (%)	sieve <212 µm (%)
Carrot 1	5.29	6.17	4.85	36.1	5.73	41.9
Carrot 2	4.85	4.41	3.96	12.3	21.6	52.9
Peas 1	0.99	1.13	1.13	10.1	2.55	84.1
Peas 2	0.43	0.71	1.13	7.66	2.98	87.1
Corn 1	11.5	2.88	4.75	7.97	4.07	68.8
Corn 2	6.10	3.05	3.81	6.44	4.07	76.4
Chicken	0.43	0.43	0.17	1.11	1.45	96.3
Mean	**4.1**	**2.6**	**4.0**	**12.7**	**5.9**	**70.1**

M.7. Dried weight (g) of particles collected on various screen mesh sizes of commercial pureed foods.

Pureed Food	Total dried wt.	% of dried	Wet Wt. (g)	Sieve 1.00 Mm (g)	sieve 850 µm (g)	sieve 600 µm (g)	sieve 300 µm (g)	sieve 212 µm (g)	Sieve <212 µm (g)
Ham	7.18	14.38	50.01	0.02	0.01	0	0.5	0.37	6.29
	7.18	14.38	50.26	0.01	0.02	0.01	0.39	0.35	6.41
Turkey	13.88	27.68	50.32	0.07	0.01	0.09	2.21	1.05	10.43
	13.88	27.68	50.03	0.15	0.03	0.06	1.43	0.96	11.21
Chicken	13.78	27.55	50.28	0.03	0.02	0.02	0.28	0.31	13.12
Pork	15.64	31.43	49.83	0.31	0.07	0.07	3.88	0.31	11.06
Brocolli	2.38	4.75	49.96	0.03	0.05	0.04	0.11	0.08	2.06
	2.38	4.75	48.92	0.03	0.01	0.01	0.11	0.12	2.09
Carrot	3.11	6.18	50.22	0	0.02	0	0.03	0.45	2.59
	3.11	6.18	50.15	0.02	0.05	0.01	0.05	0.20	2.76
Squash	1.54	3.07	49.94	0.08	0.02	0.05	0.13	0.09	1.16
	1.54	3.07	49.77	0.06	0.06	0.06	0.08	1.00	0.27
Turnip/ Apple	3.94	7.89	49.93	0.02	0.01	0.06	0.17	0.27	3.41
	3.94	7.89	50.03	0.05	0.01	0.09	0.15	0.18	3.47
Peas	7.66	15.26	49.92	0.03	0.03	0.01	0.55	0.31	6.70
	7.66	15.26	50.14	0.03	0.02	0.07	0.71	0.19	6.61
Veg	6.91	13.78	50.21	0.10	0.04	0.17	0.33	0.10	6.15
	6.91	13.78	49.83	0.16	0.03	0.18	0.33	0.16	6.03
Creamed Salmon	13.34	26.79	49.93	0.04	0.03	0	0.25	0.29	12.78
Shep. Pie	9.83	19.59	49.94	0.15	0.1	0.32	1.32	0.60	7.30
Veg Lasagna	14.79	29.65	49.94	0.05	0.04	0.07	0.15	0.14	14.37
Mac Cheese	15.78	31.6	49.93	0.2	0.05	0.05	0.26	0.13	3.04
Herbs & fish	16.18	32.26	49.99	0.11	0.09	0.28	0.82	0.43	14.40
Spag.	12.87	25.75	49.8	0.08	0.06	0.1	0.77	0.67	11.19
Mean	**8.6**	**17.1**	**50.0**	**0.1**	**0.0**	**0.1**	**0.6**	**0.4**	**6.9**

Table M.8. Percentage of particles collected on screens of various mesh sizes of commercial pureed foods.

Pureed Food	Sieve 1.00 Mm (%)	sieve 850 μm (%)	sieve 600 μm (%)	sieve 300 μm (%)	sieve 212 μm (%)	Sieve <212 μm (%)
Ham	0.28	0.01	0	6.96	5.15	87.60
Turkey	0.14	0.02	0.14	5.43	4.87	89.28
Chicken	0.5	0.01	0.65	15.92	7.56	75.14
Pork	1.08	0.03	0.43	10.30	6.92	80.76
Brocolli	0.22	0.02	0.15	2.03	2.25	95.21
Carrot	1.98	0.07	0.45	24.81	1.98	70.72
Squash	1.26	0.05	1.68	4.62	3.36	86.55
Turnip/ Apple	1.26	0.01	0.42	4.62	5.04	87.82
Peas	0	0.02	0	0.97	14.5	83.28
Veg.	0.64	0.05	0.32	1.61	6.43	88.75
Creamed Salmon	5.19	0.02	3.25	8.44	5.84	75.32
Shepherd Pie	3.9	0.06	3.90	5.20	64.9	17.53
Veg. Lasagna	0.51	0.01	1.52	4.32	6.85	86.55
Mac Cheese	1.27	0.01	2.28	3.81	4.57	88.07
Herbs & fish	0.39	0.03	0.13	7.18	4.05	87.47
Spaghetti	0.39	0.02	0.91	9.27	2.48	86.29
Mean	**1.45**	**0.04**	**2.46**	**4.78**	**1.45**	**89.31**

APPENDIX N

University of Saskatchewan
Advisory Committee on Ethics in Human Experimentation

03-Dec-2001

Certificate of Approval

PRINCIPAL INVESTIGATOR	DEPARTMENT	BMC #
Susan J. Whiting	Nutrition and Dietetics	2001-241

INSTITUTION (S) WHERE RESEARCH WILL BE CARRIED OUT

University of Saskatchewan

Saskatoon SK

SPONSORING AGENCIES

UNIVERSITY OF SASKATCHEWAN

TITLE:

Development of Fibre-Enriched Pureed Foods Using Finely Processed Pea Hull Fibre

ORIGINAL APPROVAL DATE	CURRENT EXPIRY DATE	APPROVAL OF
03-Dec-2001	01-Dec-2002	Protocol as submitted

CERTIFICATION

The University Advisory Committee on Ethics in Human Experimentation (Biomedical) has reviewed the above-named research project. The proposal was found to be acceptable on ethical grounds. The principal investigator has the responsibility for any other administrative or regulatory approvals that may pertain to this research project, and for ensuring that the authorized research is carried out according to governing law. This Certificate of Approval is valid for the above time period provided there is no change in experimental procedures

ONGOING REVIEW REQUIREMENTS

In order to receive annual renewal, a status report must be submitted to the Chair for Committee consideration within one month of the current expiry date each year the study remains open, and upon study completion. Please refer to the following website for further instructions: http:// www usask.ca/research/ethics.shtml

APPROVED.

D.W. Quest, Chair
University Advisory Committee on
Ethics in Human Experimentation

APPENDIX O

Development of Fibre-enriched Pureed Foods Using Finely Processed Pea Hull Fibre

Purpose: **The objective of this study on is to develop fibre-enriched foods that will withstand the freeze, thaw and heat cycle while maintaining optimum flavour and textural qualities. Various types of fibre ingredients will be used in the test products to predict the amount of fibre for recipe development.**

Benefits: **The results obtained will provide valuable information to predict the amount of fibre that can be added to pureed foods for use by residents of long term care.**

In consenting to participate in this study, I understand and agree with the following statements:

1. I consent to consume pureed food items that contain pea hull fibre or other dietary fibre ingredients.
2. I have been able to ask any questions I want about the study, which have been answered to my satisfaction.
3. I understand that I am ensured my privacy and anonymity; my identity will remain confidential if the results are published.
4. I understand that I am free to withdraw from participating in the study at anytime, without penalty. The withdrawal or the decision not to participate will not affect my care or the services I receive. I will have access to foods not containing the fibre source.

Contacts: If you have any questions with regards to this research project, please do not hesitate to contact any of the researchers below:

Wendy Dahl	966 2179 (work)	329 4775 (home)
Dr. Susan Whiting	966 5637 (work)	477-0214 (home)

I hereby acknowledge that the contents of the consent have been explained to me and that I have received a copy of the consent for my own records. This research has been approved by the University of Saskatchewan Advisory Committee on Ethics in Human Experimentation on April 3, 2002 and that any questions regarding your rights as a participant may be addressed to the Committee through the Office of Research Services (966-4053).

SIGNATURES
Participant: ______________________________________ Date:____________
Research Coordinator: _____________________________ Date: ____________
Witness: ____ Date: ____________

APPENDIX P

Questionnaire for Panelists

Your name: ____ Email:

1. **Have you participated on sensory evaluation panels before?**
   ______Yes ______No

   If yes,

   a) **What product(s) did you evaluate?**

   b) **Was training part of the evaluation procedure?**
   ______Yes ______No
   If yes, note the below.

2. **Are you allergic to any food products or beverages?**

   ______Yes ______No If yes, note them below.

3. **Are there any food products, beverages, food flavours or textures, that you would prefer not to evaluate?**

   ______Yes ______No If yes, note them below.

4. **Do you smoke?**

   ______Yes ______No

5. **Please indicate if you have any of the following conditions:**

   ˆDentures **ˆDiabetes**
   ˆOral or gum disease **ˆHypoglycemia**
   ˆHyperglycemia **ˆHypertension**
   ˆGastrointestinal disorder

6. **Are you currently on a restricted diet?**

   ______Yes ______No If yes, please explain.

7. **What are your favorite foods/beverages?**

8. **What are your least favorite food/beverages?**

9. **Please indicate what you believe your ability is to distinguish tastes and aromas?**

	Aroma	**Taste**
a) Better than average?	ĩ	ĩ
b) Average?	ĩ	ĩ
c) Below Average?	ĩ	ĩ

10. **Describe some of the noticeable flavours in an orange.**

11. **Describe some of the noticeable flavours in French fries.**

12. **Describe the aroma of pumpkin pie.**

13. **Describe some of the texture characteristics of vanilla pudding.**

Thank you for completing this questionnaire.

APPENDIX Q

Descriptive Sensory Analysis of Pureed Food Products

Food Product:________________

Please circle the number that most closely represents your interpretation.

On First Taste

Aroma:

1_____________2_____________3_____________4_____________5
not detectable clearly detectable

Please check your response. Acceptable aroma_____ Unacceptable aroma_____

Total flavour intensity:

1_____________2_____________3_____________4_____________5
no flavour strong flavour

Please check your response: Acceptable flavour_____ Unacceptable flavour_____

During Manipulation

Adhesiveness (stickiness to your palate):

1_____________2_____________3_____________4_____________5
not adhesive very adhesive
(vegetable oil) (peanut butter)

Cohesiveness (holds together):

1_____________2_____________3_____________4_____________5
not cohesive very cohesive
(creamed soup) (marshmallow)

Amount of particles:

1_____________2_____________3_____________4_____________5
none a lot

Particle size:

1_____________2_____________3_____________4_____________5
very fine coarse

Smoothness

1_____________2_____________3_____________4_____________5
smooth lumpy

Viscosity:

1_____________2_____________3_____________4_____________5
thin thick
(creamed soup) (peanut butter)

Residual (After swallowing)

Drying of mouth:

1_______________2_______________3_______________4_______________5

mouth feels dry — mouth feels moist

Amount of Particles:

1_______________2_______________3_______________4_______________5

none — a lot

Mouth coating:

1_______________2_______________3_______________4_______________5

none — heavy